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Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-1 Operable Unit Phase I Representative Waste Sites

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EXECUTIVE SUMMARY

This Phase I data quality objective (DQO) summary report supports the remedial investigation/feasibility study (RI/FS) and remedial action decision-making processes for the 200-PW-1 Organic Rich/Plutonium Rich Waste Group Operable Unit (OU). A RI of the 200-PW-1 OU will be conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The 200-PW-1 OU consists of eight waste sites including cribs, trenches, and two unplanned release sites. Two waste sites in the 200-PW-1 OU have tentatively been identified as representative sites in the *Waste Site Grouping for 200 Area Soil Investigations* report (DOE-RL 1997b) and the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (hereinafter referred to as the Implementation Plan) (DOE-RL 1999).

Another RI/FS DQO (Phase II) will be performed for the 200-PW-1 OU waste sites that addresses the dispersed carbon tetrachloride plume underlying a portion of the Hanford 200 West Area. The sampling requirements identified in the two DQO summary reports will be combined in the sampling and analysis plan within the 200-PW-1 OU work plan.

The waste sites in the 200-PW-1 OU received effluents from the Z Plant Complex, including the Plutonium Finishing Plant processes, which contained significant concentrations of chemicals and radionuclides. Data collected during the RI will be used to determine if the waste sites are contaminated above levels that will require remedial action, to support evaluation of remedial alternatives and/or closure strategies, and to verify or refine the preliminary conceptual contaminant distribution models. The data will be generated mainly through soil sampling and analysis.

This DQO effort follows the concepts developed in the Implementation Plan (DOE-RL 1999) for using analogous site contaminant data to reduce the amount of characterization required to support RI/FS decisions. These concepts involve grouping sites with similar process histories, structures, and contaminants and then choosing one or more representative sites for comprehensive field investigation, including sampling during RI activities. Findings from the RI

at representative sites are then used to make remedial action decisions for all of the waste sites in the OU. Nonrepresentative sites for which field data have not been (or will not be) collected are assumed to have contaminant characteristics similar to the representative sites that are characterized. A Record of Decision for the OU will be issued through the RI/FS process using the data collected during the RI. The analogous sites (i.e., those not sampled during the RI) will be addressed during the confirmatory sampling phase to ensure that the remedial action specified in the Record of Decision is appropriate and to provide design data as needed. Following remedial actions, verification samples will be collected to support site closeout.

The Washington State Department of Ecology's document, *Guidance on Sampling and Data Analysis* (Ecology 1995), was used in developing the sampling design for the RI. Because the data will not be used to demonstrate compliance with a cleanup level, focused (biased) soil sampling of areas selected with the highest contamination potential was selected over an area-wide (unbiased) sample design. The concentrations of all contaminants in each soil sample will be compared directly with the cleanup levels. A statistical analysis of the sampling data is not appropriate for focused sampling schemes and, therefore, is not used in this report. The locations of samples exceeding the cleanup level will be used to delineate the areas of soil contamination that require a decision to be made on the need for remediation.

The proposed sampling locations were selected with the goal of intersecting the areas of highest contamination and determining the vertical extent of contamination. The nature (e.g., contaminant type and concentration) and the vertical extent of the contamination are the major RI data needs. For sites that have not been adequately characterized, boreholes will be drilled to the groundwater table and soil samples will be collected at specified locations within the borehole. Geophysical logging of planned boreholes will also be performed.

The contaminants of potential concern were identified through process history information and previous data collection efforts. Analytical performance criteria were based on *Model Toxics Control Act* chemical compliance criteria (*Washington Administrative Code* 173-340) and other applicable or relevant and appropriate requirements. In the absence of applicable or relevant and appropriate requirements, other preliminary action levels were identified to determine analytical

performance criteria. These levels provide the basis for identifying the laboratory or field screening detection limits required to support remedial action decisions. A modified version of the U.S. Environmental Protection Agency's DQO guidance (EPA 1994a) was used to identify project data quality needs, to evaluate sampling and analysis options, and to document project data quality decisions.

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ACRONYMS

AA	alternative action
AEA	alpha energy analysis
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BGO	bismuth-germinate
bgs	below ground surface
BHI	Bechtel Hanford, Inc.
CAS	Chemical Abstract Service
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CHI	CH2M Hill Hanford, Inc.
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980* past-practice
CVAA	cold vapor atomic absorption
DBBP	dibutyl butyl phosphonate
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
DS	decision statement
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
FH	Fluor Hanford, Inc.
FS	feasibility study
GC	gas chromatography
GCMS	gas chromatography/mass spectrometry
GEA	gamma energy analysis
GPC	gas proportional counter
GW/VZ	Groundwater/Vadose Zone
HEIS	Hanford Environmental Information System
HPGe	high-purity germanium
IC	ion chromatography
ICP	inductively coupled plasma
ICPMS	inductively coupled plasma mass spectrometer
MCL	maximum contaminant level
MTCA	*Model Toxics Control Act*
NaI	sodium iodide
O&M	operating and maintenance
OU	operable unit
PCB	polychlorinated biphenyl

PFP	Plutonium Finishing Plan
PHMC	Project Hanford Management Contractor
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
PRF	Plutonium Reclamation Facility
PRG	preliminary remediation goal
PSQ	principal study question
PUREX	Plutonium-Uranium Extraction (Facility)
RDR/RAWP	remedial design report/remedial action work plan
REDOX	Reduction-Oxidation (Facility)
RESRAD	RESidual RADioactivity dose model
RG	rubber glove
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
RMA	remote mechanical operations "A" line
RMC	remote mechanical operations "C" line
ROD	Record of Decision
SAP	sampling and analysis plan
SGL	spectral gamma logging
STOMP	Subsurface Transport Over Multiple Phases
SVOC	semi-volatile organic compound
TBP	tributyl phosphate
TIC	tentatively identified compound
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years
UCL	upper confidence level
UPR	unplanned release
VOA	volatile organic analyte
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WDOH	Washington State Department of Health
WIDS	Waste Information Data System

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

1.0 STEP 1 – STATE THE PROBLEM

The purpose of data quality objective (DQO) Step 1 is to state the problem clearly and concisely and to ensure that the focus of the study is unambiguous.

1.1 INTRODUCTION

This Phase I summary report has been developed to support the remedial investigation/feasibility study (RI/FS) and remedial action decision-making processes for the 200-PW-1 Organic Rich/Plutonium Rich Waste Group Operable Unit (OU). A RI of the 200-PW-1 OU will be conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The 200-PW-1 OU consists of eight waste sites that include cribs, trenches, and two unplanned release (UPR) sites. Two waste sites in the 200-PW-1 OU have tentatively been identified as representative sites in the *Waste Site Grouping for 200 Areas Soil Investigations* report (DOE-RL 1997b) and the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (hereinafter referred to as the Implementation Plan) (DOE-RL 1999).

Another RI/FS DQO (Phase II) will be performed for the 200-PW-1 OU waste sites that addresses the dispersed carbon tetrachloride plume underlying a portion of the Hanford 200 West Area. The sampling requirements identified in the two DQO summary reports will be combined in the sampling and analysis plan (SAP) within the 200-PW-1 OU work plan.

The waste sites in the 200-PW-1 OU received effluents from the Z Plant Complex, including the Plutonium Finishing Plant (PFP) processes, which contained significant concentrations of chemicals and radionuclides. A map of the Hanford Site is provided in Figure 1-1 and depicts the 200 Areas and vicinity (i.e., the location of the 200-PW-1 OU). Figure 1-2 identifies the locations of the 200-PW-1 OU waste sites and the associated source facilities.

This DQO summary report focuses on the development of sampling designs for the representative (typical and worst-case) sites identified in the waste site grouping report (DOE-RL 1997b) and the Implementation Plan (DOE-RL 1999). This DQO summary report includes confirmation of the appropriate representative waste sites for implementation of the analogous site concept for this OU.

The 216-Z-1A Tile Field is a typical waste site for the 200-PW-1 OU. Waste sites in this OU received similar types of contaminants, but the estimated waste inventories vary significantly. The 216-Z-9 Trench site is the worst-case site for this OU.

Figure 1-1. Location of the Hanford Site and 200-PW-1 Operable Unit Waste Sites.

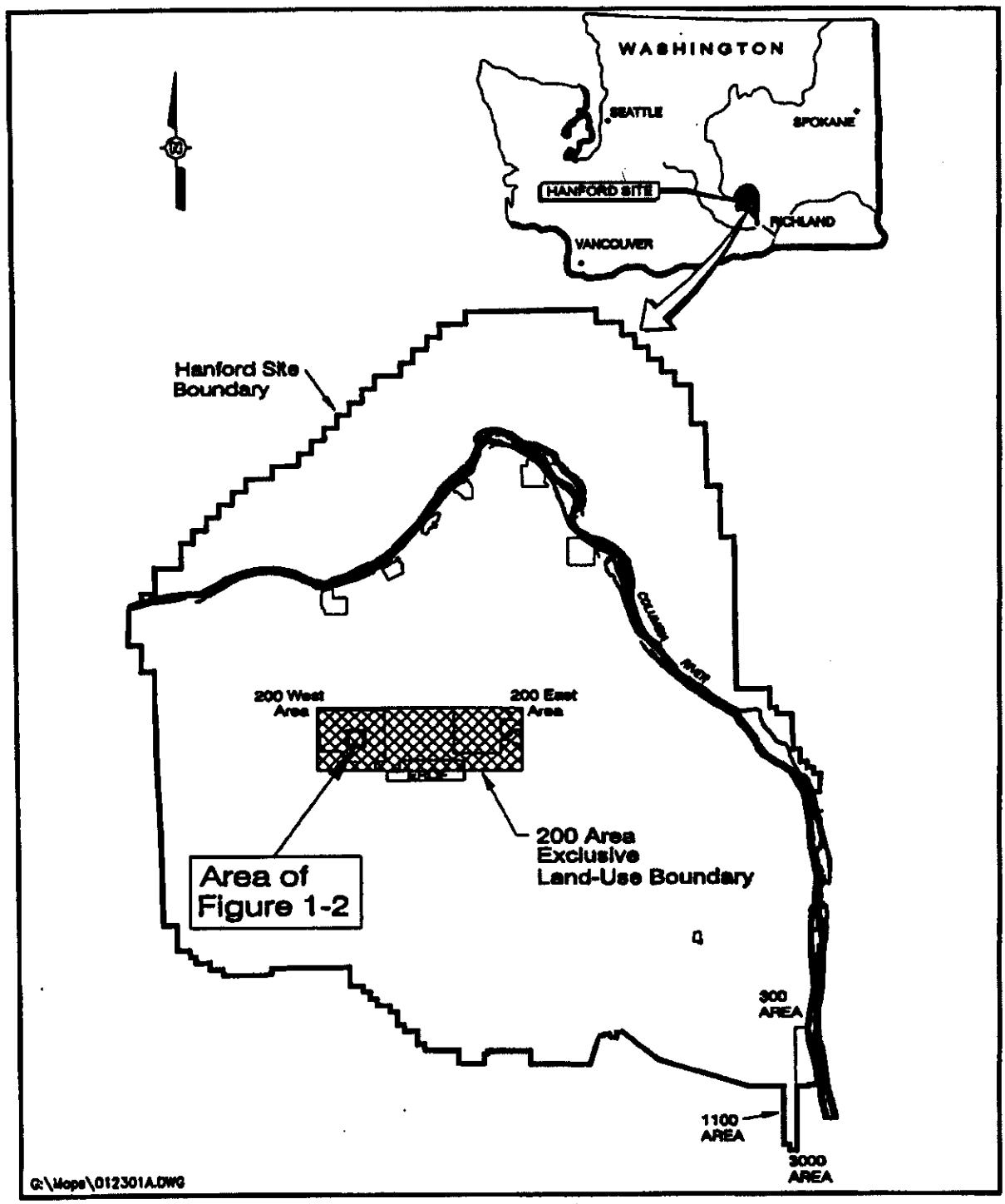
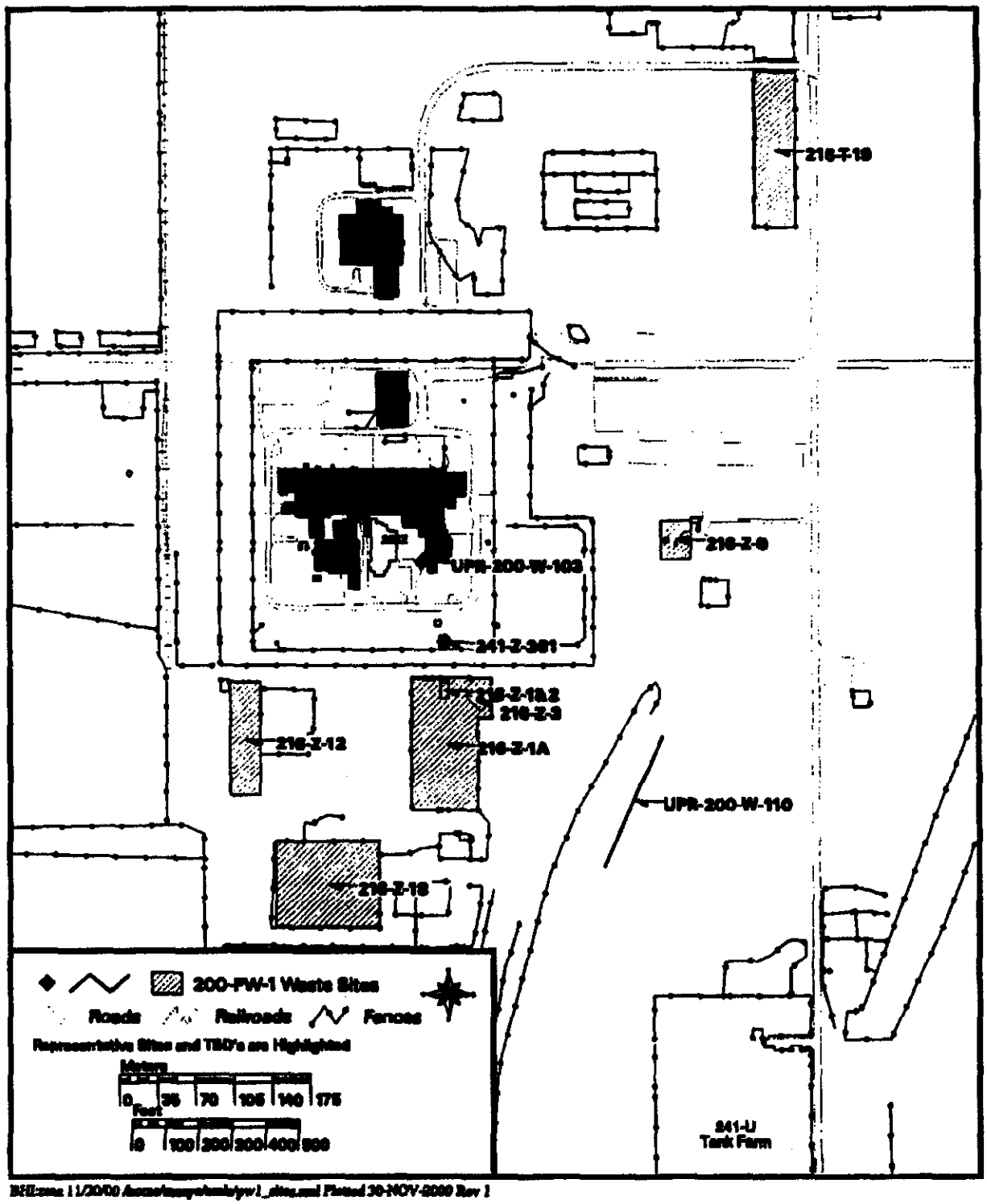


Figure 1-2. 200-PW-1 Operable Unit Waste Sites Relative to Source Facilities.



1.2 PROJECT SCOPE

This DQO summary report focuses on the representative waste sites associated with the 200-PW-1 Organic Rich/Plutonium Rich Waste Group OU. The scope of this project includes the DQO process and development of a SAP for the two representative waste sites that will be incorporated into an RI/FS work plan. The DQO summary report and SAP will provide the basis for RI of the 200-PW-1 OU using the analogous site concept.

The Implementation Plan (DOE-RL 1999) presents a consistent approach to data collection activities associated with 200 Area assessment and remediation activities. The activities include all phases of sampling required to support the completion of the CERCLA process, which is outlined in Section 2.3 and depicted in Figure 2-2 of the Implementation Plan (DOE-RL 1999). Specific activities include the following:

- Data collection at representative sites defined for the waste group-specific OU work plan, with an emphasis on verifying the conceptual contaminant distribution model(s). This will support preparation of a risk evaluation, focused feasibility study, and remedial action decision making.

- Data collection after issuance of the Record of Decision (ROD) to confirm that the analogous sites in the specific waste group OU are represented by the conceptual contaminant distribution model(s). In addition, data collection activities will be included as part of the remedy selected for the waste group to provide site-specific information for preparation of the remedial design report/remedial action work plan (RDR/RAWP).

- Verification sampling will be performed to determine that remedial objectives have been met. For the remove, treat, and dispose alternative, a RDR/RAWP will identify data collection requirements to verify that remedial action objectives have been met. For sites where wastes have been contained in place, an operating and maintenance (O&M) plan will be prepared to demonstrate adequacy of the remedial action. For example, an O&M plan would specify barrier performance monitoring activities.

This DQO process supports the data collection that will enable the evaluation of remedial alternatives and selection of a preferred alternative through the RI/FS process. Additional DQO processes will be conducted to define the sampling requirements for the other phases of data collection. The critical data needs of other Groundwater/Vadose Zone (GW/VZ) core projects will be integrated in the 200-PW-1 RI/FS work plan/SAP and are not discussed in this DQO report.

1.3 PROJECT OBJECTIVES

The objective of the DQO process for the 200-PW-1 Organic Rich/Plutonium Rich Waste Group OU is to determine the environmental measurements necessary to support the RI/FS process and remedial decision making, including refinement of the preliminary conceptual contaminant

distribution model. Additionally, the DQO process supports development of a SAP for the RI, which will be included as an appendix to the RI/FS work plan.

Possible alternatives identified in the Implementation Plan (DOE-RL 1999) include the following:

- No action alternative (no institutional controls)
- Engineered multimedia barrier
- Excavation and disposal of waste
- Excavation, ex situ treatment, and geologic disposal of TRU-contaminated soil
- In situ vitrification of soil
- In situ grouting or stabilization
- Monitored natural attenuation (with institutional controls).

1.4 PROJECT ASSUMPTIONS

Project assumptions for the RI include the following:

- The DQO process will be performed in accordance with BHI-EE-01, *Environmental Investigations Procedures*, Procedure 1.2, "Data Quality Objectives," and Section 6.1 of the Implementation Plan (DOE-RL 1999).

- The 200-PW-1 is a source OU and the investigations will focus on vadose zone soil contamination.

- The *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999) identifies land use in the near future (50 years) within the 200 Area land-use boundary as industrial (exclusive) and centers mainly on waste management activities.

- The Implementation Plan (DOE-RL 1999) outlines the assessment and remediation approach to be followed for the OU:

  - Defines the regulatory framework

  - Generally identifies the characterization approach

  - Provides background information on 200 Area site conditions, operational history, and secondary plans (e.g., quality assurance, health and safety, information management, and waste management)

  - Provides governing assumptions, including preliminary applicable or relevant and appropriate requirements (ARARs), land-use considerations, remedial action objectives, and alternatives.

- The analogous site approach will be used. Characterization will be limited to representative waste sites and the characterization will be used to reach remedial decisions for all waste sites within the OU. The DQO effort will focus on representative waste sites within the OU. Preliminary representative waste sites have been selected in the waste site grouping report (DOE-RL 1997b) and the Implementation Plan (DOE-RL 1999) that were considered to be representative of typical and worst-case conditions for the OU. Representative waste sites for the 200-PW-1 OU are as follows:

  - 216-Z-9 Trench (worst-case site)
  - 216-Z-1A Tile Field (typical site).

- Eight specific waste sites and two UPRs within the OU are listed in Appendix G of the Implementation Plan (DOE-RL 1999). Sites identified in the 200-PW-1 OU are listed below:

  - 216-T-19 Crib
  - 216-Z-1&2 Cribs
  - 216-Z-1A Tile Field
  - 216-Z-3 Crib
  - 216-Z-9 Trench
  - 216-Z-12 Crib
  - 216-Z-18 Crib
  - 241-Z-361 settling tank
  - UPR-200-W-103
  - UPR-200-W-110.

  Sampling to characterize the non-representative waste sites is not included in the scope of the 200-PW-1 work plan.

- A review of the representative sites is a key component of the DQO process. The representative sites identified in the waste site grouping report (DOE-RL 1997b) and the Implementation Plan (DOE-RL 1999) have been revisited with the DQO scoping team members and key decision makers to ensure that the appropriate sites are chosen. The final selection of representative waste sites is considered flexible (i.e., different waste sites may be selected as representative sites, or additional representative sites may be added).

- The representative waste sites in this OU are known to contain transuranic radionuclides at concentrations greater than 100 nCi/g, indicating that some of the soils would be classified as TRU-contaminated soils under U.S. Department of Energy (DOE) Guide 435.1-1 IIIA.

- Existing characterization data from 200-PW-1 waste sites and analogous data (i.e., borehole logging results from boreholes in the vicinity of the waste sites) will be used to support the DQO process and to prepare the RI/FS work plan. Based on historical site uses and current contaminant of potential concern (COPC) information, it is recognized that certain waste site contaminants of concern (COCs) will exceed action levels and that remediation will be required.

- A preliminary conceptual contaminant distribution model for the 200-PW-1 waste group in general has been developed in *Waste Site Grouping for 200 Area Soil Investigations* (DOE-RL 1997b). This preliminary conceptual contaminant distribution model provides an initial prediction of the nature and extent of the primary COCs. Models for the representative sites will be developed as part of the DQO effort and work plan preparation.

- Remedial actions will likely be required to achieve ARARs, including the industrial soil cleanup standards of the *Model Toxics Control Act* (MTCA) (*Washington Administrative Code* [WAC] 173-340) for chemical contaminants. The industrial standards are designated Method C in MTCA. The radiological dose limits will be determined in the future. For purposes of this DQO process, a dose limit range from 15 to 500 mrem/yr above natural background is applied for radionuclides in soil (refer to Global Issue #2 in Section 1.5.1). Because the waste sites in this OU are contained within the exclusive land-use boundary for the 200 Areas, an industrial land-use scenario is assumed.

- Potential data uses that need to be considered when developing DQOs include refinement of the preliminary conceptual contaminant distribution model; evaluation of remedial action alternatives, remedial action decisions, and risk assessment; and worker health and safety.

- The environmental data collected will be used to support waste disposal. A subsequent DQO process will be conducted for designation of the wastes generated during RI/FS characterization sampling.

- Wastes with mobile contaminants were disposed at these sites and may have impacted groundwater in the past. However, evaluation of groundwater contamination and remediation is not included in the scope of the work plan.

- The RI (i.e., initial OU characterization) will validate, or provide the basis to refine, the conceptual contaminant distribution models for all of the waste sites in the OU through characterization of the representative waste sites. The conceptual contaminant distribution models and the conceptual exposure model will be used to develop and evaluate remedial action alternatives applicable to the OU in a FS/closure plan. The RI/FS will form the basis for selecting a preferred remedial action in a proposed plan for the 200-PW-1 OU.

- Supplemental sampling requirements that result from integration efforts with other projects are not addressed in this DQO summary report but will be incorporated in the SAP, which will be issued following the issuance of this DQO report.

- Ecological DQOs, if established/needed, will be addressed under a 200 Area-wide investigation. Ecologically sensitive COPCs will be evaluated through that process.

1.5 PROJECT ISSUES

Project issues include the global issues that transcend the specific DQO project and the technical issues that are unique to the project. Both global and project technical issues have the potential to impact the sampling design or the DQOs for the project.

1.5.1 Global Issues

Two global issues were identified during a meeting between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy, Richland Operations Office (RL) on December 5, 2000.

- **Global Issue #1** – The 200-PW-1 OU waste sites have contributed to the carbon tetrachloride plume (vadose zone vapor and groundwater) that underlies a significant portion of the 200 West Area. Because remediation of the plume exceeds the scope of the 200-PW-1 OU waste site remedial decisions (currently under the Groundwater Management Project), it is a global issue for this project. To address this need, DOE and the Environmental Restoration Contractor (ERC) are developing a 200 Area-wide carbon tetrachloride remediation strategy under the Groundwater Management Project. The scope of this DQO process is, therefore, limited to the contiguous boundaries of the 200-PW-1 OU waste sites. Consequently, characterization of the larger groundwater and vadose zone carbon tetrachloride plume and dense non-aqueous phase liquids (DNAPLs) is not considered to be an objective of this DQO process. The critical data needs of other GW/VZ core projects will be integrated in the 200-PW-1 RI/FS work plan/SAP.

- **Global Issue #2** – The radiological dose limit for industrial land use is a global issue for this project, as the dose limit has not been established by decision makers. The EPA is evaluating radiological limits that range from 15 to 500 mrem/yr above background, with an industrial scenario yet to be defined. This issue will be further defined in the FS process and documented in the ROD for the OU.

- **Global Issue #3** – During the external DQO briefing on February 28, 2001, EPA noted that RL may not have a consistent policy for handling TRU-contaminated materials on the Hanford Site. The EPA's concern is that several of the potential remedial alternatives for the 200-PW-1 OU waste sites would leave TRU-contaminated soil in place (with or without treatment). These alternatives appear to be inconsistent with the remedial practices for other Hanford TRU waste types that will be shipped to the Waste Isolation Pilot Plant.

This DQO summary report evaluates the ability of laboratory analytical methods for radionuclide COCs to meet the DQOs (i.e., detection limits) to support the evaluation of either the upper (500 mrem/yr) and lower (15 mrem/yr) limits.

1.5.2 Project Technical Issues

The project's technical issues include the following:

- Characterization of the 200-PW-1 OU waste sites must consider radiological control requirements for possible TRU-contaminated soils at levels above the DOE definition for TRU of 100 nCi/g.

- If contaminated soils are present above the TRU level in the 200-PW-1 OU waste sites, stringent health and safety restrictions will be imposed on workers and work practices. Analyses of TRU-contaminated soils may require the use of an onsite laboratory, which could unfavorably impact analytical costs, detection limit, and analyte lists. The RI-related waste disposal options may also be affected.

- The 200-ZP-2 Project will extend two wells (299-W15-84 and 299-W15-95) approximately 30.5 m (100 ft) through the caliche formation near the 216-Z-9 Trench. Split-spoon sampling will be performed for volatile organic analytes (VOAs), metals, gross alpha and beta, plutonium (and several other radionuclides), and oil and grease, primarily for waste designation. It is possible that some of the data accumulated through this effort will meet the data quality needs for the 200-PW-1 RI/FS DQO process. The use of these data will be addressed in the SAP.

- The enclosure structure located on top of the 216-Z-9 Trench is not designed to support loads greater than those imposed by several occupational workers. The structure cannot be used to support heavy sampling equipment (e.g., drilling equipment). Because of the high contamination levels within this trench, operations that could breach the enclosure roof were deemed unacceptable. This was considered in the development of sampling design alternatives in Section 7.0.

- Several of the waste constituents within the 200-PW-1 OU waste sites have degraded to complexing agents. This may have affected the mobility of other constituents and analytical methods may not exist. These are noted in Table 1-7, where applicable.

- Although the 241-Z-361 settling tank is an analogous site within the 200-PW-1 OU, a unique remediation path may be implemented because of perceived risks associated with this site. The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) Milestone M-15-37B established the need to characterize the tank contents and structural integrity. Fluor Hanford, Inc. (FH) fulfilled this milestone, which is documented in a letter from FH to RL entitled, *Submittal of Documentation in Fulfillment of Milestone M-15-37B*, dated June 15, 2000 (FH 2000). In this letter, FH proposed a regulatory path forward that included three options: (1) a non-time critical removal action, (2) interim remedial action, and (3) deferral to the 200-PW-1 OU. The analytes reported in this characterization effort are consistent with the COCs in this DQO summary report including americium-241, neptunium-237, plutonium-238, plutonium-239/240, strontium-90, technetium-99, uranium-235, silver, cadmium, chromium, mercury, nickel, lead, tributyl

phosphate (TBP), ammonia, chloride, fluoride, nitrate, polychlorinated biphenyls (PCBs), phosphate, and sulfate.

1.6 WASTE SITES AND OPERATING HISTORY

The 200-PW-1 OU in the Hanford Site's 200 West Area includes eight CERCLA past-practice (CPP) sites and two UPR sites that received mostly acidic aqueous wastes, organic process wastes, and laboratory wastes containing relatively large amounts of americium and plutonium, with a moderate amount of uranium and small amounts of fission products. Figures 1-1 and 1-2 depict the location of the study areas relative to the 200 West Area. Waste discharged to the soil column in this OU was generated at the Z Plant Complex (which includes the PFP) from 1949 through 1980.

1.6.1 Plant History

The 231-Z Building was constructed in 1944 and served to further decontaminate the plutonium products from both T and B Plants before shipment offsite. In 1948, the 234-5 Z Building and ancillary facilities were constructed to replace the processes of the 231-Z Building. The rubber glove (RG) line was implemented in 1949. The remote mechanical operations (RMA-RMC) began in 1935 and continued until 1989. Throughout its lifetime, the Z Plant Complex received various types of processed (uranium and fission products removed) plutonium solutions from each of the 200 Area separations facilities. The major processes conducted in the Z Plant Complex included plutonium isolation and purification from the various solutions, production of metallic plutonium, and recovery of plutonium and americium from plutonium scrap solutions. Currently Z Plant's mission is the stabilization of plutonium-containing solids, solutions, and incinerator ashes and the deactivation of the facility. Several buildings were associated with the 200-PW-1 OU waste streams from Z Plant including the PFP and the RECUPLEX plutonium recovery process housed in 234-5Z, the Plutonium Reclamation Facility (PRF) in 236-Z, the americium recovery facility in 242-Z, and the Analytical and Development Laboratory.

Liquid waste generated at Z Plant was routed to an underground storage tank (e.g., 241-Z-361 settling tank) through an underground transfer system. The storage tank was used to settle the heavier constituents from the liquid effluents, forming sludge. The liquid supernatants in the tanks were ultimately discharged to the soil column via cribs, trenches, and tile fields.

The "worst-case" representative site is the 216-Z-9 Trench. This trench operated from 1955 to 1962. It received solvent and aqueous wastes from the RECUPLEX process. (The trench was the only waste site to receive solvent wastes during the RECUPLEX operation.) In 1976 and 1977, the trench floor was mined for plutonium using remotely operated equipment. Mining efforts recovered 58.1 kg (128 lb) of plutonium. Data collected during mining operations suggest that approximately 38 to 48 kg (84 to 106 lb) of plutonium remain in the soil below the trench. An enclosure structure was built to cover the trench before liquid discharges were initiated. The enclosure is reportedly not capable of supporting loads greater than the weight of two workers. A formal structural analysis has not been performed for the enclosure to date. Currently the FH Nuclear Materials Stabilization Project is responsible for the trench.

The "typical case" representative site is the 216-Z-1A Tile Field. The tile field operated from 1949 to 1969 and received effluent waste from the 234-5Z, 236-Z, and 242-Z facility operations. The tile field was originally constructed to receive liquid waste overflow from the 216-Z-1 and 216-Z-2 Cribs; however, the cribs were bypassed and the waste was routed directly to the tile field.

1.6.2 Process Information

At the Z Plant Complex, the recovered purified plutonium was refined to one of several forms depending upon the era and available process. At the start of Hanford operations, plutonium was refined in the 231-Z Building where it was converted to a nitrate paste prior to shipment offsite. Shortly thereafter, however, a more elaborate plant, the 234-5Z (i.e., PFP), was constructed with the capability to convert plutonium into metal, nitrate, or oxide forms. A number of process lines in the 234-5Z Building were used between 1949 and 1989. Initially batch inorganic chemical steps were used to refine and convert plutonium to the desired form, and elaborate mechanical extraction processes were developed later. The PFP was used to fabricate plutonium into weapons shapes and to reprocess scrap plutonium using solvent extraction techniques based on TBP mixed with carbon tetrachloride (RECUPLEX). Processes at the Z Plant Complex that generated the primary waste streams into the 200-PW-1 OU waste sites included the following (it should be noted that 200-PW-1 waste sites did not receive any waste from the 231-Z Building and its operations):

- Rubber glove (RG) line: Operation was then transferred to the newly constructed 234-5 Building in 1949 and operated until 1953, when it was abandoned for remote mechanical operations. Waste generated by this process included hydrofluoric, sulfuric, and nitric acids, as well as peroxide, plutonium, and other transuranic metals.

- Remote mechanical "A" (RMA) line: The RMA line was constructed in 1949 and began operations in 1953. The RMA line operated until it was upgraded to remote mechanical C (RMC) operations. The process was the same as the RG line chemically; however, the plutonium was handled by remote mechanical means. Thus, the RMA produced the same waste as the RG line.

- Remote mechanical "C" (RMC) line: The RMC line was constructed in 1957 and began operations in 1960. The RMC operated until 1973 and again from 1985 to 1989. The process was the same as the RG and RMA lines chemically; however, the plutonium was handled remotely by mechanical means, with additional mechanical upgrades to increase the safety of the operators. Thus, the RMC produced the same waste as the RG and RMA lines.

- Plutonium Metal Fabrication: Weapons-grade plutonium metal was cut and milled into weapons shapes for quick assembly into nuclear weapons in the late 1950s. Waste generated by this process included mixed lard oil and carbon tetrachloride, as well as other volatile organics used as cutting fluids.

- RECUPLEX: This plutonium recovery process operated in the 234-5Z Building from 1955 to 1962, at which time the process was terminated after a criticality event (i.e., an

uncontrolled nuclear reaction) within the PFP. Waste generated by this process included hydroiodic, hydrofluoric, sulfuric, and nitric acids, as well as silver, carbon tetrachloride, TBP, plutonium, and other transuranic metals.

- Americium recovery: An americium recovery process operated in the 242-Z Building between 1964 and 1976. The process was shut down in 1976 after an explosion occurred in one of the recovery units. Waste generated by this process included hydrochloric, hydrofluoric, phosphoric, and nitric acids, as well as dibutyl butyl phosphonate (DBBP), carbon tetrachloride, TBP, plutonium, and other transuranic metals.

- Plutonium Reclamation Facility (PRF): In 1964, a replacement plutonium scrap solution recovery facility, the PRF, was brought on line in the 236-Z Building. The PRF operated from 1964 to 1979 and from 1984 to 1987. Waste generated by this process included hydrofluoric, phosphoric, and nitric acids, as well as silver, hydroxyl amines, DBBP, carbon tetrachloride, TBP, uranium, plutonium, and other transuranic metals.

Tables 1-1, 1-2, 1-3, and 1-4 identify the DQO scoping team members, DQO workshop team members, DQO integration team members, and key decision makers, respectively. The scoping team developed the DQO checklist and binder prior to the internal seven-step process. The DQO workshop team members participated in the seven-step DQO process. The key decision makers provided external review of the results of the seven-step process.

Table 1-1. DQO Scoping Team Members. (2 Pages)

Name	Organization	Area of Expertise (Role)
Janet Badden	CHI Regulatory Support/ Environmental Science	Regulatory
Roy Bauer	CHI Environmental Engineering	DQO Workbook/Facilitator
Steve DeMers	BHI Radiological Control Engineering	Radiological Control Engineering
Bruce Ford	BHI Site Assessments	200 Area Remedial Action Task Manager
Lyle Ivey	CHI Regulatory Support/Environmental Science	Statistician
John Ludowise	CHI Environmental Engineering	200-PW-1 Task Lead, Process Knowledge
Jim Sharpe	CHI Regulatory Support/ Environmental Science	Cultural/Biological Issues
Kevin Singleton	CH2M Hill, Inc.	Geosciences Technical Staff, Author
Dave St. John	CHI Sample/Data Management	Sampling Data Management/Site Sampling History
Wendy Thompson	BHI Environmental Technologies	Sampling/Field Analysis
Rich Weiss	CHI Sample/Data Management	Radiochemical and Analytical, Data Management

Table 1-1. DQO Scoping Team Members. (2 Pages)

Name	Organization	Area of Expertise (Role)
Curt Wittreich	CHI Environmental Engineering	200 Area Remedial Action Lead
Michelle Yates	CHI Environmental Engineering	Process Chemistry, Technical Staff, Author

BHI = Bechtel Hanford, Inc.
CHI = CH2M Hill Hanford, Inc.

Table 1-2. DQO Workshop Team Members.

Name	Organization	Area of Expertise (Role)
Kim Anselm	CHI Office Services	Project Assistant/Document Control
Janet Badden	CHI Regulatory Support	Regulatory Compliance
Roy Bauer	CHI Environmental Engineering	DQO Facilitator/Workbook
Bruce Ford	BHI Environmental Leads	200 Area Remedial Action Task Manager
John Ludowise	CHI Environmental Engineering	CHI Project Lead
Virginia Rohay	CHI Geosciences/Modeling	Technical Staff
Jim Sharpe	CHI Environmental Engineering	Scoping – Cultural Resources
Kevin Singleton	CH2M Hill, Inc.	Geology
Rob Sitzler	BHI Radiological Control Engineering	Environmental Radiological Engineering
Wendy Thompson	BHI Environmental Technologies	Sampling and Analysis Collection
Rich Weiss	CHI Sample/Data Management	Analytical Laboratory
Curt Wittreich	CHI Environmental Engineering	CHI 200 Area Project Lead
Michelle Yates	CHI Environmental Engineering	Scoping – 200 Area Processes/ Chemistry

Table 1-3. DQO Integration Team Members.

Name	Organization	Area of Expertise (Role)
Keith Hampton	FH	241-Z-361 Settling Tank
Virginia Rohay	200-ZP-1 and 200-ZP-2	Technical Staff/Coordination
Craig Swanson	200-ZP-1 and 200-ZP-2	Technical Staff

Table 1-4. DQO Key Decision Makers.

Name	Organization	Area of Expertise (Role)
Dennis Faulk	EPA	EPA OU Manager
Bryan Foley	DOE	DOE Project Manager

Table 1-5 lists the key sources of existing documents and data collected from previous investigations that were reviewed by the DQO team.

Table 1-5. Existing Documents and Data Sources for 200-PW-1 Operable Unit. (3 Pages)

Reference	Summary
200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program, DOE/RL-98-28, Rev. 0 (DOE-RL 1999)	Background geography, process, waste site, and COC knowledge, and strategy for the 200 Areas.
200 Areas Waste Sites Handbook, 3 vols., RHO-CD-673 (Maxfield 1979)	Waste site descriptions, releases, waste discharge information, and management reports.
1994 Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford Site, WHC-SD-EN-TI-248, Rev. 0 (Rohay 1994)	Provides data summaries and analytical results from limited field investigations conducted at 216-Z-1A and 216-Z-9. Geological information and COPC, COC, and carbon tetrachloride information.
Distribution of Plutonium and Americium Beneath the 216-Z-1A Crib: A Status Report, RHO-ST-17 (Price et al. 1979)	Provides data summaries and analytical results from limited field investigations at 216-Z-1A. Contains geological, COPC, and COC information.
Report on Plutonium Mining Activities at 216-Z-9 Enclosed Trench, RHO-ST-21 (Ludowise 1978)	Provides data summaries and analytical results of plutonium inventories before and after removal at 216-Z-9. Provides logistical data of mining activities and current condition of the trench.
Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915 (Smith 1973)	Provides data summaries and analytical results of plutonium inventories at 216-Z-9 before removal.
Hanford Site Atlas, BHI-01119, Rev. 1 (BHI 1998)	Site maps.
WIDS reports for 200-PW-1: 216-T-19 Crib, 216-Z-1&2 Cribs, 216-Z-1A Tile Field, 216-Z-3 Crib, 216-Z-9 Trench, 216-Z-12 Crib, 216-Z-18 Crib, 241-Z-361 settling tank, UPR-200-W-103, UPR-200-W-110	Summarizes site names, locations, types, status, site and process descriptions, associated structures, cleanup activities, environmental monitoring description, access requirements, references, regulatory information, and waste information (e.g., type, category, physical state, description, and stabilizing activities).
Performance Evaluation Report for Soil Vapor Extraction Operations at the Carbon Tetrachloride Site, February 1992-September 1999, BHI-00720, Rev. 4 (Rohay 2000)	Provides data summaries and updated results of limited field investigations for the 200 West Area with respect to carbon tetrachloride and selected VOAs.

Table 1-5. Existing Documents and Data Sources for 200-PW-1 Operable Unit. (3 Pages)

Reference	Summary
Description of work documents for the 216-Z-9 Trench, which are currently being developed by the ERC Groundwater/Vadose Zone Integration Project (to be published)	Information on COCs. Will also provide geological and vadose zone information.
Submittal of Documentation in Fulfillment of Milestone M-15-37B, letter FH-000279, to RL, dated June 15, 2000 (FH 2000)	Information on COCs.
Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium Plumes in the 200 West Area: 1994 to 1999 Update, BHI-01311, Rev. 0 (BHI 1999)	Geological and groundwater information.
DNAPL Investigation Report, BHI-00431, Rev. 0 (BHI 1995)	Geological information.
241-Z-361 Sludge Characterization Data Quality Objectives, HNF-4225, Rev. 0 (LMHC 1999)	Historical waste site and COC disposal information for 241-Z-361 tank.
216-Z-12 Transuranic Crib Characterization: Operational History and Distribution of Plutonium and Americium, RHO-ST-44 (Kasper 1982)	Historical waste site, operational, geological, and COC disposal information.
Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells, ARH-ST-156 (Fecht et al. 1977)	Geophysical logs and contaminant distribution data.
Hanford Site Groundwater Monitoring for Fiscal Year 1998, PNNL-12086 (PNNL 1999a)	Groundwater annual report information.
PNLATLAS/LG-ARCHV/200 East and West	Database for geophysical logging.
Z Plant Liquid Waste Disposal Through the 241-Z Vault, ARH-CD-323 (ARH 1976)	Historical waste site, operational, geological, and COC disposal information.
Hanford Sitewide Groundwater Remediation Strategy, DOE/RL-94-95, Rev. 1 (DOE-RL 1997a)	Groundwater and geological information.
History and Stabilization of the Plutonium Finishing Plant (PFP) Complex, Hanford Site, HNF-EP-0924 (Gerber 1997)	Historical account of process operations information for Z Plant and ancillary facilities, and feed process modifications at REDOX, PUREX, and T and B Plants. Provides information on trouble encountered, solutions implemented, chemical used, an overview of each processes' daily activities, building construction, functions, maintenance, and sampling, laboratory, and disposal activities.
200 Areas Disposal Sites for Radioactive Liquid Wastes, ARH-947 (Curren 1972)	Waste site and COC information.
Radionuclide Inventories of Liquid Waste Disposal Sites on the Hanford Site, HNF-1744 (FH 1999)	Waste site and COC information.

Table 1-5. Existing Documents and Data Sources for 200-PW-1 Operable Unit. (3 Pages)

Reference	Summary
Waste Site Grouping for 200 Areas Soil Investigations, DOE/RL-96-81, Rev. 0 (DOE-RL 1997b)	Summarizes site name, location, type status, site and process descriptions, known and suspected contamination, preliminary contaminant distribution conceptual model, site conditions that may affect COC fate and transport, COC mobility in Hanford Site soils, COC distribution and transport to groundwater, and hazards associated with COCs. Soil porosity information for each waste site.
Results of 1998 Spectral Gamma-Ray Monitoring of Boreholes at the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib, PNNL-11978 (PNNL 1999b)	Spectral gamma logging data in the 216-Z-1A Tile Field and around the 216-Z-9 Trench.
Proof-of-Principle Demonstration of a Passive Neutron Tool for Detection of TRU-Contaminated Soil at the 216-Z-1A Tile Field, BHI-01436, Rev. 0 (Bauer et al. 2000)	Gross gamma logs and passive neutron results in two boreholes in the 216-Z-1A Tile Field, confirming TRU-contaminated soils in the tile field.
Z Plant Source Aggregate Area Management Study Report, DOE/RL-91-58, Rev. 0 (DOE-RL 1992)	Soil and geological information, COPC information, process history, and geophysical logging.
HEIS database	Well information and sampling data.
Discussions with Mr. Thurman D. Cooper, PFP Chemist	Historical process and operation information and COPC listings.
Discussions with Mr. David A. Dodd, PFP Chemist	Historical process and operation information and COPC listings.
Site visit notes	Information on general site conditions.
Drawings	Construction "as-built" drawings of individual waste sites.

HEIS = Hanford Environmental Information System
PUREX = Plutonium-Uranium Extraction (Facility)
REDOX = Reduction-Oxidation (Facility)
WIDS = Waste Information Data System

Table 1-6 represents the complete, unconstrained set of COPCs that were, or could have been, discharged to the 200-PW-1 OU waste sites. The master COPC list was then evaluated against a set of exclusion rationale to determine the final list of project COCs. The COPCs that were excluded and the rationale for their exclusion are listed in Table 1-7.

Table 1-6. Sources of Contamination, COPCs, and Affected Media for the 200-PW-1 Operable Unit. (2 Pages)

Known or Suspected Source of Contamination (Process)	Type of Contamination from Each Source (General Contamination)	Affected Media
The 200-PW-1 OU waste sites received plutonium-rich and organic-rich wastes from the RECLUPLEX and PRF processes, PFP operations including RMA, RMC, and americium recovery operations, and laboratory wastes, all from the Z Plant Complex.	These wastes contained inorganic anions and cations, acidic, and large amounts of organic waste with high levels of plutonium and americium-241, moderate amounts of uranium, and lower amounts of fission products.	Shallow soils (0 to 4.6 m [15 ft] bgs) and deep soils (>4.6 m [>15 ft] bgs) associated with the waste sites and groundwater beneath the waste sites.

Radioactive COPCs			
Americium-241	Curium-242	Plutonium-240	Strontium-90
Americium-242	Curium-243	Plutonium-241	Technetium-99
Americium-243	Curium-244	Plutonium-242	Thorium-232
Antimony-123	Curium-245	Protactinium-233	Tritium
Antimony-125	Lanthanum-140	Radium-224	Uranium-232
Cerium-141	Lead-212	Radium-226	Uranium-233
Cerium-144	Lead-214	Radium-228	Uranium-234
Cesium-134	Neptunium-237	Ruthenium-103	Uranium-235
Cesium-135	Neptunium-239	Ruthenium-106	Uranium-236
Cesium-137	Plutonium-238	Strontium-89	Uranium-238
Cobalt-60	Plutonium-239		

Inorganic COPCs			
Aluminum	Ammonium oxalate	Calcium nitrate	Hydroxide
Aluminum fluoride	Ammonium fluorosilicate	Chloride	Lanthanum
Aluminum nitrate	Ammonium sulfate	Fluoride	Lanthanum fluoride
Aluminum nitrate (mono basic)	Arsenic nitrate	Gallium oxide	Lanthanum hydroxide
Aluminum sulfate	Bismuth	Hydrochloric acid	Lanthanum nitrate
Ammonia	Cadmium nitrate	Hydrofluoric acid	Lithium chloride
Ammonium hydroxide	Calcium	Hydroiodic acid	Magnesium
Ammonium lanthanum nitrate	Calcium carbonate (lime)	Hydrogen	Magnesium oxide
	Calcium iodide	Hydrogen peroxide	Mercury
	Calcium fluoride		

Inorganic Chemical COPCs			
Nickel	Plutonium dioxide	Sodium bicarbonate	Sodium sulfate
Nitrate	Plutonium nitrate	Sodium carbonate	Sulfate
Nitric acid	Plutonium peroxide	Sodium chloride	Sulfuric acid
Peroxide	Potassium permanganate	Sodium fluoride	Uranium
Phosphate	Selenium	Sodium hydroxide	Uranium dioxide
Phosphoric acid	Silver	Sodium nitrate	Uranium trioxide
Plutonium	Sodium	Sodium oxalate	Uranyl nitrate
Plutonium fluoride	Sodium aluminate		

Table 1-6. Sources of Contamination, COPCs, and Affected Media for the 200-PW-1 Operable Unit. (2 Pages)

Known or Suspected Source of Contamination (Process)	Type of Contamination from Each Source (General Contamination)		Affected Media
Organic Chemical COPCs			
1,1-dichloroethane (DCA) 1,2-dichloroethane (DCA) 1,1,1-trichloroethane (TCA) Benzene Carbon tetrachloride Cis-1,2-dichloroethylene Chlorobenzene	Chloroform DBBP Dibutyl phosphate Ethylbenzene Hydraulic fluids (greases) Hydrogen dibutyl phosphate Hydroxylamine Hydroxylamine Hydrochloride	Methyl ethyl ketone (MEK) Methyl iso butyl ketone (MIBK) Methylene chloride Miscellaneous cutting oils (lard and other oils) Monobutyl phosphate n-butyl benzene Normal paraffins	Oxalic acid Phenol PCBs Toluene Tetrachloroethylene (PCE) Trans-1,2-dichloroethylene TBP Trichloroethylene (TCE) Xylene

Table 1-7. 200-PW-1 Operable Unit COPC Exclusions and Justifications. (3 Pages)

COPCs	Rationale for Exclusion
Radionuclides	
Americium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Americium-243	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Antimony-123	Stable.
Antimony-125	Short-lived radionuclide (half-life <3 years).
Cerium-141	Short-lived radionuclide (half-life <3 years).
Cerium-144	Short-lived radionuclide (half-life <3 years).
Cesium-134	Short-lived radionuclide (half-life <3 years).
Cesium-135	Constituent generated at less than 5E-5 times the Cs-137 activity.
Curium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Curium-243	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Curium-244	Constituent with atomic mass number greater than or equal to 242 that represents less than 1% of the actinide activity. May be reported via americium isotopic analysis.
Curium-245	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Lanthanum-140	Short-lived radionuclide (half-life <3 years).
Neptunium-239	Short-lived radionuclide (half-life <3 years).
Plutonium-241	Not detected by normal plutonium analysis, can infer from americium/plutonium results.

Table 1-7. 200-PW-1 Operable Unit COPC Exclusions and Justifications. (3 Pages)

COPCs	Rationale for Exclusion
Plutonium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Protactinium-233	Even though Pa-233 was detected during spectral gamma logging performed at boreholes in the representative sites referenced by Price et al. (1979), it is a daughter product and can be calculated from Np-237.
Radium-224	Value can be calculated from Th-232 if present.
Radium-226	GEA will report if detectable quantities are present.
Radium-228	GEA will report if detectable quantities are present.
Ruthenium-103	Short-lived radionuclide (half-life <3 years).
Ruthenium-106	Short-lived radionuclide (half-life <3 years).
Strontium-89	Short-lived radionuclide (half-life <3 years).
Uranium-232	<2E-3 times the U-238 activity.
Uranium-233	Measurement cannot resolve U-233 + U-234 isotopes, reported as U-234 or U-233/234.
Uranium-236	Measurement cannot resolve U-235 + U-236 isotopes, reported as U-235.
Inorganics	
Aluminum	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Bismuth	This inorganic substance is unlikely to be present in toxic concentrations.
Calcium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Carbonate(axb)	This inorganic substance is unlikely to be present in toxic concentrations.
Gallium	This inorganic substance is unlikely to be present in toxic concentrations.
Hydrogen	Gas.
Hydroxide	Assessed via pH determination.
Iodine	This inorganic substance is unlikely to be present in toxic concentrations.
Iron	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Lanthanum	This inorganic substance is unlikely to be present in toxic concentrations.
Lithium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Magnesium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Manganese	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Peroxide	Has degraded.

Table 1-7. 200-PW-1 Operable Unit COPC Exclusions and Justifications. (3 Pages)

COPCs	Rationale for Exclusion
Potassium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Silicon	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Sodium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Organics	
Dibutyl butyl phosphonate	DBBP was widely used as a solvent during the PRF americium recovery operations. No direct standard analytical procedure available. Will degrade to phosphate and detected in those analytical measurements.
Dibutyl phosphate	No direct standard analytical technique available. This compound is a degradation product of TBP and is unlikely to be present in toxic or high concentrations. This compound will be detected as TBP (TIC).
Hydroxylamine	No direct standard analytical technique available. Hydroxylamine was used during the PRF processes.
Hydroxylamine hydrochloride	No direct standard analytical technique available. Hydroxylamine hydrochloride was used during the PRF processes.
Miscellaneous cutting oils (lard and other oils)	No direct standard analytical technique available. These compounds are not likely to be present in toxic or high concentrations. They may, however, be detected by the analyses performed for the hydraulic fluids or the normal paraffins.
Monobutyl phosphate	No direct standard analytical technique available. This compound is a degradation product of TBP and is unlikely to be present in toxic or high concentrations. This compound will be detected as TBP (TIC).
Oxalate	Oxalate and oxalic acids were used during the plutonium isolation (RG, RMA, and RMC) operations. No direct standard analytical technique available. Oxalate has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants.

GEA = gamma energy analysis
ICP = inductively coupled plasma
TIC = tentatively identified compound

Based on a review of process, operations, and waste discharge information from various sources (Table 1-5), the chemical behavior of the constituents was evaluated. Process knowledge indicates that the 200-PW-1 OU waste streams were predominantly liquid effluent discharges from the plutonium purification by solvent extraction processes performed at Z Plant. In general, the waste generated can be described as plutonium and organic-rich, discharged mainly from the RECLUPLEX and PRF processes. Additional waste streams from PFP operations included the RG line, remote mechanical (RMA and RMC) operations, the americium recovery process, and laboratory waste. This waste contained inorganic anions and cations, acids, and large amounts of organic waste with high levels of plutonium and americium-241, moderate amounts of uranium, and lower amounts of fission products.

The first step in the evaluation process involved extracting known toxic materials from the master COPC list for placement on the final COC list. Inorganic salts and acids represent a large group of constituents in the waste sites being evaluated. Because laboratory analyses are generally not acid- or compound-specific, the acids and inorganic salts were excluded from further consideration. Instead, the readily detected cations and anions (e.g., metals, fluorides, and nitrates) associated with the acids and inorganic salts serve as the target constituents for those compounds. This logic recognizes the small volumes of hazardous and radiological constituents released into large-volume aqueous discharges.

The analytical approach employed for this project generally targets the significant risk drivers that are representative of the waste constituents present. The general suite-type analytical techniques yield results on many metals and organic compounds, providing a cost-effective approach for the known toxic materials that could be present.

The COPCs in the following categories were excluded from further consideration:

- Short-lived radionuclides with half-lives less than 3 years
- Radionuclides that constitute less than 1% of the fission product inventory and for which historical sampling indicates nondetection
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Constituents with atomic mass numbers greater than 242 that represent less than 1% of the actinide activities
- Progeny radionuclides that build insignificant activities within 50 years and/or for which parent/progeny relationships exist that permit progeny estimation
- Constituents that would be neutralized and/or decomposed by facility processes
- Chemicals in a gaseous state that cannot accumulate in soil media
- Chemicals used in minor quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals are not likely to be present in toxic or high concentrations
- Chemicals that are not persistent in the environment due to biological degradation or other natural mitigating features.

Table 1-8 includes the final list of COCs for the 200-PW-1 OU waste sites, with the rationale for inclusion for each of the COCs.

Table 1-8. 200-PW-1 Operable Unit Final COC List. (4 Pages)

Final COCs	Rationale for Inclusion
Radiological Constituents	
Americium-241	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Cesium-137	Known fission product (GE 1944 [Sections A, B, and C], GE 1951b).
Cobalt-60	Known fission product (GE 1944 [Sections A, B, and C], GE 1951b, WHC 1991).
Hydrogen-3 (tritium)	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Neptunium-237	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Plutonium-238	Known production from fission reaction (GE 1944, Sections A, B, and C). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Plutonium-239	Known production from fission reaction (GE 1944, Sections A, B, and C). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Plutonium-240	Known production from fission reaction (GE 1944, Sections A, B, and C). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Strontium-90	Known fission product (GE 1944 [Sections A, B, and C], GE 1951b). Analyzed as total radioactive strontium. Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Technetium-99	Known fission product (GE 1944 [Sections A, B, and C], WHC 1991). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Thorium-232	Known production from fission reaction (GE 1944 [Sections A, B, and C], FH 1999).
Uranium-234	Known feed from fission reaction (GE 1944, Sections A, B, and C).
Uranium-235	Known feed from fission reaction (GE 1944, Sections A, B, and C). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Uranium-238	Known feed from fission reaction (GE 1944, Sections A, B, and C).
Nonradiological Constituents – Metals	
Arsenic	Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Cadmium	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).

Table 1-8. 200-PW-1 Operable Unit Final COC List. (4 Pages)

Final COCs	Rationale for Inclusion
Chromium	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Chromium (VI)	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Copper	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Lead	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Mercury	Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Nickel	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Selenium	Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Silver	Analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Nonradiological Constituents – General Inorganics	
Ammonia/ammonium	Several compounds contained ammonium. The most widely used included ammonium silica fluoride, which was used as a cleaning and decontamination compound based on the ability to dissolve metals and fission products (GE 1944 [Section C], GE 1951b, HEW 1945). Also used in PRF processes (discussions/publications by Thurman D. Cooper, PFP Chemist). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Chloride	Several compounds contained chloride. The most widely used included Lithium chloride, which was used as a salting agent, and hydrochloric acid, which was used as a carrier during the americium recovery operations (discussions/publications by Thurman D. Cooper, PFP Chemist). Also, residual waste from the bismuth-phosphate process (GE 1944 [Section C], GE 1951b, HEW 1945). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Fluoride	Several compounds contained fluoride the most widely used included hydrofluoric acid, a stripping solvent used in the RG, RMA, RECLUPLEX, PRF, and americium recovery operations (discussion/publications by Thurman D. Cooper, PFP Chemist). Lanthanum fluoride (which was used during the concentration operations of the bismuth-phosphate process) was also a large carry-over waste product (GE 1944 [Section C], GE 1951b, HEW 1945). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).

Table 1-8. 200-PW-1 Operable Unit Final COC List. (4 Pages)

Final COCs	Rationale for Inclusion
Nitrate/nitrite	Several compounds contained nitrates/nitrites the most widely used included nitric acid, a stripping solvent used in the RG, RMA, RECLUPLEX, PRF, and americium recovery operations (discussion/publications by Thurman D. Cooper, PFP Chemist). Nitric acid and various salts were also used throughout the bismuth-phosphate, Uranium Recovery Project, REDOX, and PUREX processes to isolate plutonium from various fission products (GE 1944 [Section C], GE 1951a, GE 1951b, GE 1955). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Phosphate	Several compounds contained phosphate. The most widely used included TBP and its derivatives and DBBP, which was used RECLUPLEX, PRF, and americium recovery operations (discussion/publications by Thurman D. Cooper, PFP Chemist). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Sulfate	Several compounds contained sulfate. The most widely used included sulfuric acid, which was used as a persulfate-leaching step in the RECLUPLEX, PRF, and americium recovery operations (discussion/publications by Thurman D. Cooper, PFP Chemist). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Volatile Organics	
1,1-dichloroethane (DCA)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
1,2-dichloroethane (DCA)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
1,1,1-trichloroethane (TCA)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Acetone	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Benzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Carbon tetrachloride	Carbon tetrachloride was widely used as a dilutant for TBP and DBBP in the RECUPLEX, PRF, and americium-241 recovery processes. Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone and has impacted groundwater (Rohay 1994).
Cis-1,2-dichloroethylene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Chlorobenzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Chloroform	Chloroform is a degradation product of carbon tetrachloride. Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose (Rohay 1994).
Ethylbenzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).

Table 1-8. 200-PW-1 Operable Unit Final COC List. (4 Pages)

Final COCs	Rationale for Inclusion
Hydraulic fluids (greases)	Several types of hydraulic fluids were used during the milling and cutting of plutonium buttons and/or rods.
Methyl ethyl ketone (MEK)	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone (Rohay 1994).
Methyl iso butyl ketone (MIBK)	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone (Rohay 1994).
Methylene chloride	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone (Rohay 1994).
n-butyl benzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Toluene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Tetrachloroethylene (PCE)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Trans-1,2-dichloroethylene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Trichloroethylene (TCE)	TCE is a degradation product of carbon tetrachloride. Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone and has impacted groundwater (Rohay 1994).
Xylene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Semi-Volatile Organics	
Normal paraffins (greases and oils)	Various types of normal paraffins were used as milling, cutting, and washing solutions during the production of plutonium buttons/rods.
PCBs	Various types of normal paraffins were used as milling, cutting, and washing solutions during the production of plutonium buttons/rods. These solutions almost always contained PCBs (discussions/publications with David A. Dodd, PFP Chemist). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Phenol	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
TBP and derivatives (mono, bi)	Extensive use in solvent extraction operation of RECLUPLEX, PRF, and americium recovery operations (discussions/publications with David A. Dodd, PFP Chemist). Analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).

The final COC list for this DQO process was developed for the representative waste sites. Process knowledge indicates that this list is also appropriate for the analogous sites within the 200-PW-1 OU. It should be noted, however, that the 216-T-19 Crib received unique T Plant second-cycle bismuth/phosphate wastes in addition to the Z Plant wastes. Screening the master list of COPCs for the 216-T-19 Crib would result in the addition of the following unique

contaminants to Table 1-8: carbon-14, europium-152, europium-154, europium-155, and nickel-63. Because these constituents are not associated with the representative sites, the samples collected during remedial characterization will not include these analytes. This unique condition will be addressed during the confirmatory sampling performed in the remedial design phase for the 216-T-19 Crib.

Table 1-9 defines the ARARs and preliminary remediation goals (PRGs) for each COC.

Table 1-9. List of Preliminary ARARs and PRGs. (2 Pages)

COCs	Preliminary ARARs	PRGs
Radionuclides Inside the 200 Area Industrial Land-Use Boundary [a]		
Shallow zone (0 to 4.6 m [0 to 15 ft] bgs)	15 to 500 mrem/yr above background[b] via industrial land-use scenario while under DOE control; 15 mrem/yr above background at the end of the exclusive-use period if DOE control is relinquished; 4 mrem/yr above background to groundwater; or no additional groundwater degradation.	Contaminant-specific; RESRAD modeling[c]
Deep zone (>4.6 m [>15 ft] bgs)	4 mrem/yr above background to groundwater, or no additional groundwater degradation.	MCLs, state and Federal ambient water quality control criteria; alternatively, site-specific modeling
Nonradiological Constituents Inside the 200 Area Industrial Land-Use Boundary		
Shallow zone (0 to 4.6 m [0 to 15 ft] bgs)	MTCA Method C, and 100 times groundwater	Chemical-specific
Deep zone (>4.6 m [>15 ft] bgs)	100 times groundwater (in accordance with MTCA)	Alternatively, site-specific modeling
TRU Waste Definition		
Any depth zone	Radioactive waste containing more than 100 nCi of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years except for (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the EPA, does not need the degree of isolation required by the 40 CFR 191 disposal regulations; or (3) waste that the U.S. Nuclear Regulatory Commission has approved on a case-by-case basis in accordance with 10 CFR 61.[d]	Contaminant-specific

Table 1-9. *List of* Preliminary ARARs and PRGs. (2 Pages)

COCs	Preliminary ARARs	PRGs
Greater Than Class C Waste		
Any depth zone	10 CFR 61.55	Contaminant-specific

[a] Based on *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999) (see Figure 1-1).
[b] The 200 Area radionuclide cleanup standard for the industrial land-use scenario has not been established. This will be agreed upon in the ROD. The EPA is currently evaluating cleanup standards that range from 15 to 500 mrem/yr above background.
[c] RESRAD has been used for similar waste sites and will be used as a minimum for direct exposure. If more appropriate models are developed, the models will be evaluated for use.
[d] Working definition of TRU waste as stated in DOE Guide 435.1.

bgs = below ground surface
CFR = *Code of Federal Regulations*
MCL = *maximum contamination level*
RESRAD = RESidual RADioactivity dose model

Table 1-10 lists the general exposure scenarios.

Table 1-10. General Exposure Scenarios.

Scenario No.	General Exposure Scenario Description
1	Industrial land-use scenario (inside the 200 Area land-use boundary)[a]: The source of contamination in the 200-PW-1 OU is the liquid effluent disposed to the waste sites. The near-term release mechanism is direct radiation exposure to occupational workers in the vicinity of the waste sites (although shielded by stabilizing cover). Ingestion and inhalation of surface or subsurface soils in an occupational scenario does not represent a substantial exposure due to waste site surface stabilization and the limited soil ingestion and inhalation anticipated during excavation activities in an industrial setting (e.g., use of dust control measures limits exposures). Downward migration of mobile constituents into the groundwater would not affect occupational workers, as their drinking water source would not be the underlying aquifers. However, the protection of groundwater is a requirement and must be addressed by evaluating potential future impacts.
	The exposure time is divided into time spent inside and outside an industrial facility: • Building occupancy: 8 hours/day x 0.6 (building occupancy factor), 5 days/week, 50 weeks/yr, for 20 years (of a 75-year lifetime). • Outdoor exposure: 8 hours/day x 0.4 (outdoor exposure factor), 5 days/week, 50 weeks/yr, for 20 years (of a 75-year lifetime). In addition, the building occupancy exposure includes a factor of 0.4 to reduce the ingested dust component due to building ventilation system filtration. Biota that may be exposed to contaminants in this OU will be addressed under a separate 200 Area-wide evaluation. Remedial actions to address human health concerns will also serve to protect biota.

[a] The *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999) (see Figure 1-1) identifies the actual and near future (50-yr) land use within the 200 Area land-use boundary as industrial (exclusive) and would center mainly on waste management activities.

Table 1-11 provides the regulatory milestones and regulatory drivers associated with this project.

Table 1-11. Regulatory Milestones.

Milestone	Due Date	Regulatory Driver
M-13-26	June 29, 2001	Tri-Party Agreement milestone to submit 200-PW-1 Plutonium Rich/Organic Rich Waste Group work plan (Draft A) to EPA.

The project milestones and their drivers are listed in Table 1-12.

Table 1-12. Project Milestones.

Milestone	Due Date	Driver
Internal DQO workshop	January 15, 2001	DQO schedule
External DQO briefing	February 15, 2001	
Issue DQO summary report	February 28, 2001	DQO documentation

As noted in the project assumptions, the DQO scoping team concurred on selection of representative waste sites for the 200-PW-1 OU.

Table 1-13 combines the relevant background information into a concise statement of the problem to be resolved for this DQO process.

Table 1-13. Preliminary Conceptual Contaminant Distribution Model Discussion and Concise Statement of the Problem. (3 Pages)

Preliminary Conceptual Contaminant Distribution Model[a]:
Plutonium-rich and organic-rich waste streams associated with the plutonium recovery processes at the Z Plant Complex were discharged to the 200-PW-1 OU waste sites. The Z Plant Complex was used to process plutonium nitrate solutions into plutonium oxide and plutonium metal. These process streams contained recoverable quantities of plutonium that were reclaimed during RECLUPLEX and PRF operations. This waste also contained inorganic anions and cations, acids, large amounts of organic waste, high amounts of plutonium and americium-241, moderate amounts of uranium, and lower amounts of fission products. Additional waste streams were generated from the americium recovery operations and the Z Plant laboratory. The RECLUPLEX and PRF are primary sources of carbon tetrachloride in the 200-West Area.
Waste streams discharged at the 200-PW-1 OU waste sites contained a variety of constituents, including carbon tetrachloride, americium, plutonium, and uranium. The organic solutions, which contained carbon tetrachloride as DNAPL, constituted 4% to 8% of the total volume of liquid waste discharged. The predominant discharge was an acidic, high-salt (sodium nitrate) solution composed primarily of nitric acid, fluoride, nitrate, and phosphate, containing plutonium and americium with an organic content of less than 1% dissolved carbon tetrachloride.

Table 1-13. Preliminary Conceptual Contaminant Distribution Model Discussion and Concise Statement of the Problem. (3 Pages)

Effluent and contaminants (carbon tetrachloride as DNAPL and in the dissolved aqueous form, plutonium-239/240, americium-241, and uranium) were discharged directly to the soil column at liquid waste receiving sites. The wetting front and contaminants infiltrated the soil column. Effluent and contaminant(s) migration is predominately vertically downward beneath the waste site. Lateral spreading is primarily associated with finer grained strata. Older, poorly sealed wells that perforate the Plio-pleistocene Unit and/or penetrate the water table may provide a localized vertical conduit for fluids along the outside well casing. Clastic dikes and discontinuous sand- and gravel-filled randomly oriented features also provide preferential pathways for solution movement through the finer strata. Carbon tetrachloride migrates through the vadose zone under its own hydraulic gradient. As DNAPL migrates downward, part of the liquid carbon tetrachloride will be held as residual liquid (i.e., DNAPL, dissolved, and absorbed phases) in the soil pores by capillary forces. In addition, some of the liquid carbon tetrachloride will be retained in the vadose zone through mechanisms such as sorption to soil (adsorbed phase) and entrapment of DNAPL/dissolved liquids in dead-end pore spaces. Residual contamination of both phases will be left along the contaminant migration path. Carbon tetrachloride also volatilizes from the DNAPL and aqueous phase to form a vapor phase in the soil pore space. Vapor phase migration is by molecular diffusion and advection. Sediment density, stratification, and variability also influence fluid and vapor migration patterns.

All carbon tetrachloride phases (except DNAPL) have been found throughout the vadose zone beneath the representative sites (Rohay 2000). The highest carbon tetrachloride concentration in sediment samples collected was 37.8 ppm and 6.6 ppm beneath 216-Z-9 Trench and 216-Z-1A Tile Field, respectively. At both locations, maximum concentrations are associated with the interbedded sands and silts of the Hanford formation lower fine unit, laminated silts of the Plio-pleistocene Unit, and/or the top of the caliche. Other volatile organic compounds detected include methylene chloride, chloride, trichloroethylene (TCE), tetrachloroethylene (PCE), trans-1,2-DCE, 1,1-DCA, 1,2-DCA, cis-1,2-DCE, 1,1,1 TCA, benzene, xylenes, and toluene (Rohay 2000).

Plutonium and americium are typically retained in the upper few meters of the soil column (WHC 1993) when released in a dissolved aqueous phase. Because of their large distribution coefficients (K_ds), they normally adsorb strongly to Hanford soils. At the 216-Z-1A Tile Field, these radionuclides were discharged as co-contaminants with the DNAPL-complexant mixture (TBP) and are found deep within the vadose zone. Contaminants such as tritium and nitrate with low K_ds are not readily adsorbed on soil particles and migrate with the wetting front. The maximum vertical extent of plutonium and americium contamination in 1979 was interpreted to be located approximately 30 m (98 ft) below the bottom of the crib and 30 m (98 ft) above the 1978 water table (Price et al. 1979). Year 2000 depth-to-water measurements indicated that the surface of the water has dropped 3.4 m (11 ft). Spectral gamma performed in the 1990s indicated that radiological contamination may extend to 37 m (121 ft). The estimated lateral extent of radiological contamination is located within a 10-m (32.8-ft)-wide zone encompassing the perimeter of the crib (Price et al. 1979). The distribution of contaminants deep within the vadose zone suggest that plutonium and americium mobility is highly enhanced in the presence of carbon tetrachloride, TBP and derivatives, acidic liquid waste effluents, and other complexants. The exact transport mechanism of the observed plutonium/americium is not known at this time. Further investigation is needed.

More than half of the waste sites in the 200-PW-1 OU received small quantities of effluent relative to estimated soil pore volumes. The effluent volume discharged to the 216-Z-1A Tile Field is 12% of the estimated soil pore volume. The 216-Z-9 Trench received 142% of its estimated soil pore volume. This information suggests that the wetting front has migrated through the vadose zone beneath the 216-Z-9 Trench and has reached the water table. The wetting front may not have reached groundwater at the 216-Z-1A Tile Field.

Table 1-13. Preliminary Conceptual Contaminant Distribution Model Discussion and Concise Statement of the Problem. (3 Pages)

Only the dissolved phase of carbon tetrachloride has been detected in groundwater. The plume of dissolved carbon tetrachloride extends over 11 km^2 (4.4 mi^2) in the unconfined aquifer underlying the 200 West Area. The area of highest concentrations (4,000 to 8,000 $\mu g/L$) in the past included the 216-Z-9 Trench. Carbon tetrachloride discharged to the trench may be providing a continuous source of contamination to groundwater. The distribution of carbon tetrachloride vapor below the Plio-pleistocene layer suggests that these vapors may have volatilized from the dissolved groundwater plume throughout the 200-West Area (Rohay 2000). Major nonradiological groundwater plumes in the vicinity of representative sites in addition to carbon tetrachloride include chloroform, trichloroethylene, and nitrate. There are no major radiological plumes in the vicinity of representative sites (PNNL 2000).

The preliminary conceptual contaminant distribution models for 200-PW-1 OU, the 216-Z-1A Tile Field, and the 216-Z-9 Crib are shown in Figures 1-3, 1-4, and 1-5, respectively.

DQO Approach:

The DQO process for the 200-PW-1 OU is being performed to determine if representative sites have been contaminated to levels that require remedial action.

The outcome of the characterization being developed in this DQO process for the representative sites will be applied to the other analogous sites. A SAP will be developed after completion of the DQO process, which will specify the sampling and analyses to be performed for characterization of the five representative sites.

All of the waste sites associated with this OU are located within the 200 Area industrial land-use boundary line and will be evaluated on the basis of future industrial uses.

Problem Statement:

The problem is to determine contaminant concentrations and soil physical parameters in the representative sites to support evaluation of remedial alternatives in the FS and to verify or refine the conceptual contaminant distribution models.

[a] The preliminary conceptual contaminant distribution model will become the conceptual contaminant distribution model after acceptance of this DQO summary report and will then be applied to the project work plan.

Figure 1-3. Conceptual Exposure Model for the 200-PW-1 Operable Unit.

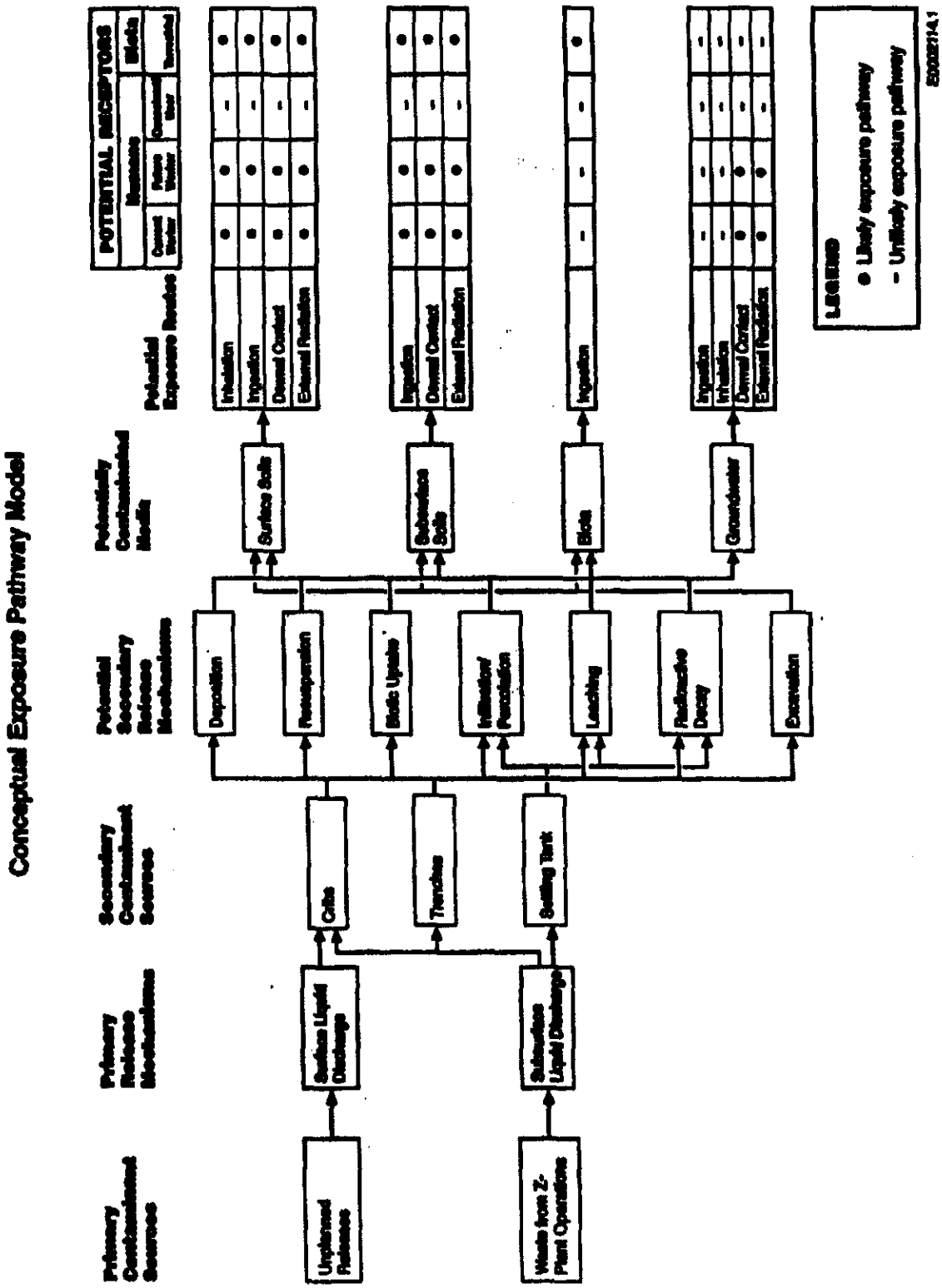
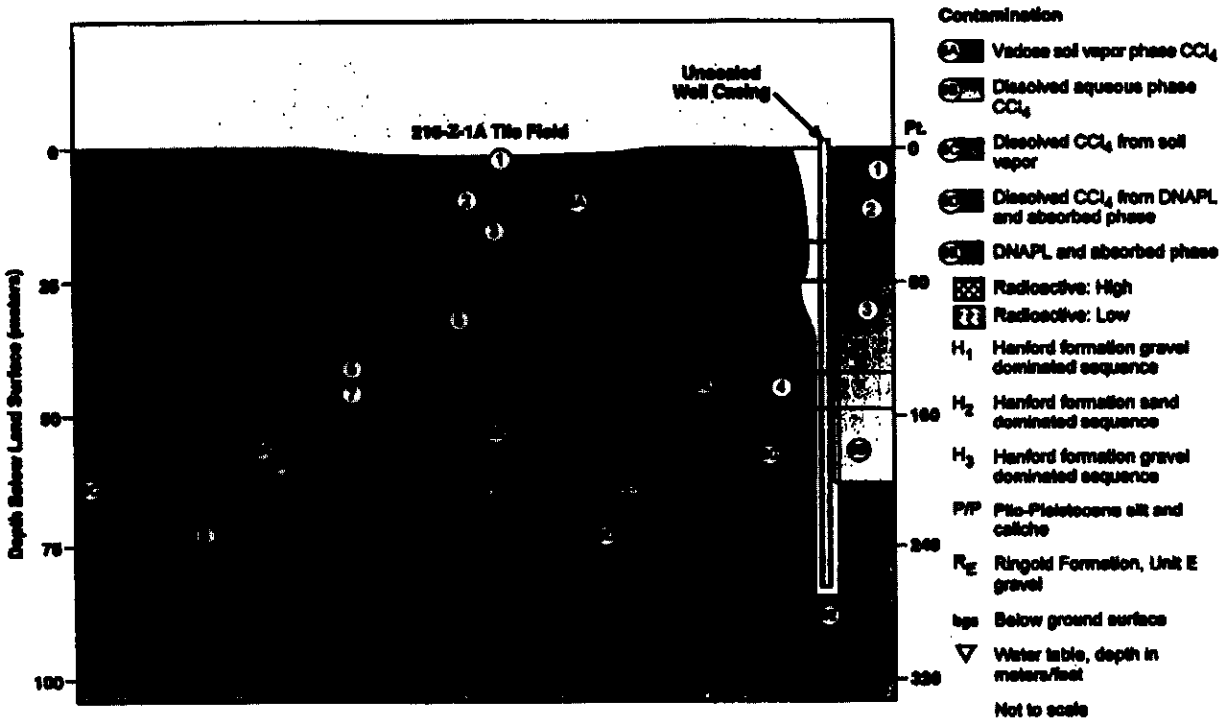


Figure 1-4. Preliminary Conceptual Contaminant Distribution Model for the 216-Z-1A Tile Field.



① Plutonium/organic rich process wastes were discharged to the 216-Z-1A Tile Field between 1949 and 1969. The tile field received 6.2×10^8 L of high-salt acidic liquid waste that contained 57 kg plutonium, 3.4 kg americum, and approximately 268,000 kg carbon tetrachloride.

② Effluent and contaminants were released to the environment near the bottom of the tile field through a herringbone arrangement of pipes into the H_1 soils.

③ The wetting front and contaminants move vertically beneath the tile field. There is little or no lateral spreading unless it is associated with the Plio-Pleistocene Unit or fine-grained lenses in the Hanford formation. However, a vapor phase of carbon tetrachloride is present throughout the vadose zone in the source area.

④ Older boreholes, and possibly clastic dikes, may provide preferential pathways through the vadose zone.

⑤ Constituents with large distribution coefficients, such americium and plutonium, sorb to soils with higher concentrations near the discharge pipe at the bottom of the tile field. These constituents are typically not detected deep within the vadose zone. Beneath the tile field, radionuclides were detected to a depth of 30 to 37 m. The distribution of these contaminants deep within the vadose zone indicate that plutonium and americium mobility is highly enhanced in the presence of carbon tetrachloride, TBP and derivatives, acidic liquid waste, and other complexants discharged. Their concentrations generally decrease with depth.

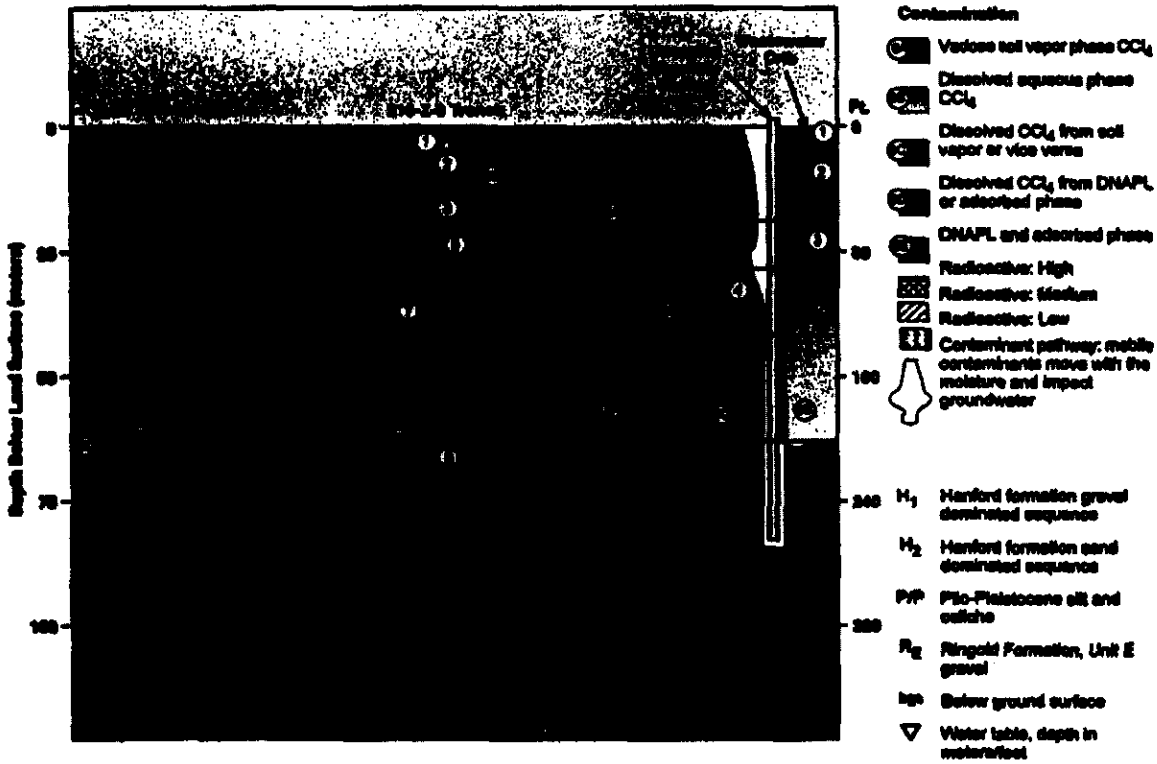
⑥ Carbon tetrachloride is present throughout the vadose zone beneath the 216-Z-1A Tile Field. As determined from sample and empirical data, carbon tetrachloride exist as a vapor (6A), dissolved aqueous phase in the effluent discharged (6B), dissolved aqueous phase produced from soil vapor (6C), dissolved aqueous phase from DNAPL and the absorbed phase (6D), and DNAPL and the adsorbed phase (6E). The presence of DNAPL has not been confirmed in soil samples.

⑦ The highest concentration of carbon tetrachloride is detected associated with Plio-Pleistocene Unit.

⑧ The effluent volume discharged (12% of the soil pore volume) to the tile field suggest that groundwater may not have been directly impacted by the wetting front unless a preferential pathway is present. Carbon tetrachloride in the groundwater may be associated with soil vapor phase, preferential movement, and adjacent facilities.

B0102038.2

Figure 1-5. Preliminary Conceptual Contaminant Distribution Model for the 216-Z-9 Trench.



① Plutonium/organic rich process wastes were discharged to the 216-Z-9 trench between 1955 and 1962. The trench received 4.09 x 10^8 L of high-salt acidic waste water that contained approximately 47 kg plutonium, 8.6 kg americium, 0.05 kg uranium, and 1.32 to 4.77 x 10^5 kg carbon tetrachloride.

② Effluent and contaminants were released to the environment at the bottom of an acid-resistant, tile-lined trench. The bottom of the trench is in H_1.

③ The wetting front and contaminants move vertically beneath the crib. There is little or no lateral spreading unless it associated with the Plio-Pleistocene Unit or fine-grained lenses in the Hanford formation. However, a vapor phase of carbon tetrachloride is present throughout the vadose zone in the source area.

④ Older boreholes, and possibly clastic dikes, may provide preferential pathways through the vadose zone.

⑤ Constituents with large distribution coefficients, such americium and plutonium, sorb to soils with higher concentrations near the discharge pipe at the bottom of the trench. These constituents typically are not detected deep within the vadose zone. Beneath the trench, these contaminants were detected to a depth of 36.9 m. The distribution of these contaminants deep within the vadose zone indicate that plutonium and americium mobility is highly enhanced in the presence of carbon tetrachloride, TBP and derivatives, acidic liquid waste, and other complexants discharged. Their concentrations generally decrease with depth.

⑥ Carbon tetrachloride is present throughout the vadose zone beneath the 216-Z-9 Trench. As determined from sample and empirical data, carbon tetrachloride exists as a vapor (6A), dissolved aqueous phase in the effluent discharged (6B), dissolved aqueous phase produced from soil vapor (6C), dissolved aqueous phase from DNAPL and the absorbed phase (6D), and DNAPL and the adsorbed phase (6E). The presence of DNAPL has not been confirmed in soil samples.

⑦ The highest concentration of carbon tetrachloride is detected associated with Plio-Pleistocene Unit.

⑧ The effluent volume discharged (142% of the soil pore volume) and presence of carbon tetrachloride in groundwater indicates that waste disposal practices at the crib have impacted the aquifer. Plutonium and americium have occasionally been detected in the groundwater near the trench.

Step 1 – State the Problem

2.0 STEP 2 – IDENTIFY THE DECISION

The purpose of DQO Step 2 is to define all of the principal study questions (PSQs) that need to be resolved to address the problems identified in DQO Step 1 and the alternative actions (AAs) that would result from resolution of the PSQs. The PSQs and AAs are then combined into decision statements (DSs) that express a choice among AAs. Table 2-1 presents the task-specific PSQs, AAs, and resulting DSs. This table also provides a qualitative assessment of the severity of the consequences of taking an incorrect AA. This assessment takes into consideration human health and the environment (flora/fauna) and political, economic, and legal ramifications. The severity of the consequences is expressed as low, moderate, or severe.

Table 2-1. Summary of DQO Step 2 Information. (2 Pages)

PSQ-AA #	Alternative Action	Consequences of Erroneous Actions	Severity of Consequences
PSQ #1 – Are the contaminant concentrations TRU or greater than Class C?			
1-1	Evaluate special remedial alternatives in a FS.	Special remedial alternatives for the waste sites will be unnecessarily developed during the FS. The remedial alternative will unnecessarily incorporate costly and difficult processes for handling TRU or greater than Class C contaminated soil.	Low
1-2	Evaluate conventional remedial alternatives in a FS.	The FS and associated remedial action will not plan for special remedial alternatives necessary for handling TRU or greater than Class C contaminated soils. These soils might be incorrectly managed and disposed. Workers could be exposed to unacceptable levels of radioactively contaminated soils during remediation.	Severe
DS #1 – Determine whether the contaminant concentrations are TRU or greater than Class C and evaluate special remedial alternatives in a FS, or evaluate conventional remedial alternatives in a FS.			
PSQ #2 – Is the soil radiologically contaminated?			
2-1	Evaluate remedial alternatives in a FS.	The site may be inappropriately remediated resulting in unnecessary expenditure of funds.	Low
2-2	Evaluate the site for closure with no remedial action.	The site may inappropriately be closed without remedial action, increasing risks of potential exposure to workers and the environment.	Severe
DS #2 – Determine whether the soil is radiologically contaminated and evaluate remedial alternatives in a FS, or evaluate the site for closure with no remedial action.			
PSQ #3 – Is the soil chemically contaminated?			
3-1	Evaluate remedial alternatives in a FS.	The site may be inappropriately remediated resulting in unnecessary expenditure of funds.	Low

Table 2-1. Summary of DQO Step 2 Information. (2 Pages)

PSQ-AA #	Alternative Action	Consequences of Erroneous Actions	Severity of Consequences
3-2	Evaluate the site for closure with no remedial action.	The site may inappropriately be closed without remedial action, increasing risks of potential exposure to workers and the environment.	Severe
DS #3 – Determine whether the soil is chemically contaminated and evaluate remedial alternatives in a FS, or evaluate the site for closure with no remedial action.			

3.0 STEP 3 – IDENTIFY THE INPUTS TO THE DECISION

The purpose of DQO Step 3 is to identify the types of data needed to resolve each of the DSs identified in DQO Step 2. The data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., practical quantitation limit [PQL], precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.1 BASIS FOR SETTING THE PRELIMINARY ACTION LEVEL

The preliminary action level is the threshold value that provides the criteria for choosing between AAs. Table 3-1 identifies the basis (i.e., regulatory threshold or risk-based) for establishing the preliminary action level for each of the COCs. The numerical value for the action level is defined in DQO Step 5.

Table 3-1. Basis for Setting Preliminary Action Level.

DS #	COCs	Basis for Setting Preliminary Action Level	Preliminary Action Levels
1	TRU-contaminated soils	DOE's definition for TRU waste (DOE Guide 435.1).	100 nCi/g
	Greater than Class C contaminated soils	10 CFR 61 definition of greater than Class C waste.	>100 nCi/g[a]
2	Radiological COCs	Radiological lookup values for shallow zone soils based on RESRAD analyses for the applicable scenarios. Deep zone lookup values TBD.	Refer to Table 3-6
3	Nonradiological COCs	MTCA Method C cleanup levels with contaminant-specific variations.	Refer to Table 3-6

[a] This limit applies to alpha emitting radionuclides with half-lives over 5 years in accordance with 10 CFR 61.55.
N/A = not applicable
TBD = to be determined (using a vadose zone transport model co-selection process)

3.2 INFORMATION REQUIRED TO RESOLVE DECISION STATEMENTS

Table 3-2 specifies the information (data) required to resolve each of the DSs identified in Table 2-1 and identifies whether the data already exist. For the data that are identified as existing, the source references for the data have been provided with a qualitative assessment as to whether or not the data are of sufficient quality to resolve the corresponding DS.

Table 3-2. Required Information and Reference Sources. (5 Pages)

DS #	Required Information Category	Do Data Exist? (Y/N)	Source Reference	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)		Are Additional Data Required to Support RI/FS Process? (Y/N)	
				Z-9	Z-1A	Z-9	Z-1A
1	Soil TRU-contamination and greater than Class C status	Y	*Distribution of Plutonium and Americium Beneath the 216-Z-1A Crib: A Status Report*, RHO-ST-17 (Price et al. 1979). Provides data summaries and results from limited field investigations at 216-Z-1A.	N/A	Y	N/A	Y[a]
			Report on Plutonium Mining Activities at 216-Z-9 Enclosed Trench, RHO-ST-21 (Ludowise 1978). Provides data summaries and results of plutonium inventories before and after mining efforts at 216-Z-9.	Y	N/A	Y[a]	N/A
			Z Plant Source Aggregate Area Management Study Report, DOE/RL 91-58, Rev. 0 (DOE-RL 1992).	Y	Y	Y[a]	Y[a]
			Results of 1998 Spectral Gamma-Ray Monitoring of Boreholes at the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib, PNNL-11978 (PNNL 1999b).	N/A	Y	N/A	Y[a]
			Proof-of-Principle Demonstration of a Passive Neutron Tool for Detection of TRU-Contaminated Soil at the 216-Z-1A Tile Field, BHI-01436, Rev. 0 (Bauer et al. 2000).	N/A	Y	N/A	Y[a]
			Waste Site Grouping for 200 Areas Soil Investigations, DOE/RL-96-81, Rev. 0 (DOE-RL 1997b). Provides existing information for the wastes sent to this OU.	Y	Y	Y[a]	Y[a]
			Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915 (Smith 1973). Provides data summaries and analytical results of plutonium inventories before removal at 216-Z-9.	Y	N/A	N	N/A

Table 3-2. Required Information and Reference Sources. (5 Pages)

DS #	Required Information Category	Do Data Exist? (Y/N)	Source Reference	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)		Are Additional Data Required to Support RI/FS Process? (Y/N)	
				Z-9	Z-1A	Z-9	Z-1A
2	Soil radiological data	Y	*1994 Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford*, WHC-SD-EN-TI-248, Rev. 0 (Rohay 1994). Provides data summaries and results from limited field investigations at 216-Z-1A and 216-Z-9.	Y	Y	Y[a,b]	Y[a,b]
			Distribution of Plutonium and Americium Beneath the 216-Z-1A Crib: A Status Report, RHO-ST-17 (Price et al. 1979). Provides data summaries and results from limited field investigations at 216-Z-1A.	N/A	Y	N/A	Y[a,b]
			Report on Plutonium Mining Activities at 216-Z-9 Enclosed Trench, RHO-ST-21 (Ladowise 1978). Provides data summaries and results of plutonium inventories before and after removal at 216-Z-9.	Y	N/A	Y[a,c]	N/A
			Z Plant Source Aggregate Area Management Study Report, DOE/RL 91-58, Rev. 0 (DOE-RL 1992).	Y	Y	Y[a,b,c]	Y[a,b,c]
			Results of 1998 Spectral Gamma-Ray Monitoring of Boreholes at the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib, PNNL-11978 (PNNL 1999b).	Y	Y	Y[a]	Y[a]
			Proof-of-Principle Demonstration of a Passive Neutron Tool for Detection of TRU-Contaminated Soil at the 216-Z-1A Tile Field, BHI-01436, Rev. 0 (Bauer et al. 2000).	N/A	Y	N/A	Y[a]

Table 3-2. Required Information and Reference Sources. (5 Pages)

DS #	Required Information Category	Do Data Exist? (Y/N)	Source Reference	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)		Are Additional Data Required to Support RI/FS Process? (Y/N)	
				Z-9	Z-1A	Z-9	Z-1A
2	Soil radiological data	Y	*Waste Site Grouping for 200 Areas Soil Investigations*, DOE/RL-96-81, Rev. 0 (DOE-RL 1997b). Provides existing information for the wastes sent to the 200-PW-1 OU.	N	N	Y[a]	Y[a]
			Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915 (Smith 1973). Provides data summaries and analytical results of plutonium inventories before removal at 216-Z-9.	N[b]	N/A	Y[a]	N/A
3	Soil nonradiological sample data	Y	*Performance Evaluation Report for Soil Vapor Extraction Operations at the Carbon Tetrachloride Site, February 1992-September 1999*, BHI-00720, Rev. 4 (Rohay 2000). Provides data summaries and updated results of limited field investigations for the 200 West Area with respect to carbon tetrachloride and selected VOAs.	N	N	Y	Y
			1994 Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford, WHC-SD-EN-TI-248, Rev. 0 (Rohay 1994). Provides data summaries and results from limited field investigations at 216-Z-1A and 216-Z-9.	N[a]	N[a]	Y	Y
N/A	Groundwater data	Y	*DNAPL Investigation Report*, BHI-00431, Rev. 0 (BHI 1995). Provides DNAPL data for well W15-32 drilled near the 216-Z-9 Trench.	Groundwater data cannot be used to validate a vadose zone preliminary conceptual contaminant distribution model.			

Table 3-2. Required Information and Reference Sources. (5 Pages)

DS #	Required Information Category	Do Data Exist? (Y/N)	Source Reference	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)		Are Additional Data Required to Support RI/FS Process? (Y/N)	
				Z-9	Z-1A	Z-9	Z-1A
N/A	Groundwater data	Y	*Hydrostratigraphy and Recharge Distributions from Direct Measurements of Hydraulic Conductivity Using the UFA Method*, PNL-9424 (PNL 1994). Presents results of physical property analyses (saturation, hydraulic conductivity, pore volume, water content, particle size, mineralogy, and density) from samples collected at wells near 216-Z-9 and 216-Z1A in 1992 and 1993.	Groundwater data cannot be used to validate a vadose zone preliminary conceptual contaminant distribution model.			
1, 2, and 3	Physical properties moisture content, particle size distribution, and lithology	Y	*Hydrogeologic Model for the 200-West Groundwater Aggregate Area*, WHC-SD-EN-TI-014, Rev. 0 (WHC 1992). Presents site-specific data for 200 West Area that can be used to calculate soil density, hydraulic conductivity, and porosity.	N	N	Y	Y
	Distribution coefficients		*Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, PNNL-11800 (PNNL 1998). Provides 200 Area distribution coefficients for various waste stream types and Hanford soils.	N	N	Y	Y
			Geochemical Data Package for the Hanford Immobilized Low-Activity Tank Waste Performance Assessment (ILAW PA), PNNL-13037, Rev. 1 (Kaplan and Serne 2000). Provides 200 Area distribution coefficients for various waste stream types and Hanford soils.	N	N	Y	Y

Table 3-2. Required Information and Reference Sources. (5 Pages)

DS #	Required Information Category	Do Data Exist? (Y/N)	Source Reference	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)		Are Additional Data Required to Support RI/FS Process? (Y/N)	
				Z-9	Z-1A	Z-9	Z-1A
1 and 2	RESRAD input data	Y	*Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0*, ANL-EAD-LD-2 (ANL 1993). Input parameters are defined in this manual that can be determined based on existing information or RESRAD defaults.	N	N	Y	Y
1, 2, and 3	Vadose transport (STOMP) code-based model input data	Y	*Subsurface Transport Over Multiple Phases (STOMP)*, PNNL-12034 (PNNL 2000). Site configuration inputs needed to develop site-specific model.	N	N	Y	Y

[a] Historical data indicated that these sites contain TRU-contaminated and radiologically contaminated soils. However, data gaps do exist, particularly in the deeper vadose zone. Therefore, additional data are needed to complete the vertical contaminant profile.

[b] Data were not collected in a primary sampling location. The data were collected during soil/vapor extraction, therefore organic analyses are not considered accurate because of the effectiveness of the extraction system in reducing organic vapors from the vadose zone. In addition, the quality of the data needs to be further investigated to validate sample results.

[c] Data were collected in a primary sampling location; however, the data were only collected to a depth of 3.1 m (10 ft) below the trench surface, and only for Cd, Am-241, Cs-137, Pu-239/240, Sr-90, and soil gas vapor. Thus, additional data are needed.

N/A = not applicable
STOMP = Subsurface Transport Over Multiple Phases

3.2.1 Data Gap Analysis

The data in the reference source documents were evaluated for adequacy to support the RI/FS decision-making process (see Table 3-2). The data review indicated that there are no data gaps for TRU-contamination and radiological contamination in the upper regions of the vadose zone (0 to 17 m [58 ft] depth for the 216-1A Tile Field and 0 to 21 m [105 ft] for the 216-Z-9 Trench). However, TRU contamination and radiological contamination data gaps exist for both sites below those elevations.

These sites were historically a concern from a radiological standpoint; consequently, little chemical characterization data exists. The data that do exist cover few of the contaminants in Table 1-8 and over limited depth intervals.

Because the deeper portions of the vadose zone lack radionuclide data and because chemical constituent data are missing for the entire vadose zone, the RI/FS decision-making process was evaluated for sensitivity to these data gaps. The remove, treat, and dispose alternative is the most sensitive to the TRU contamination and radiological contamination concentrations in the shallow depth zones. The historical information satisfies the data needs; however, the engineered multimedia barrier alternative requires contaminant information in the deep vadose zone to assess waste site conditions against barrier performance. Therefore, it was concluded that these data gaps must be filled to support evaluation for all of the remedial alternatives being considered.

3.3 COMPUTATIONAL AND SURVEY/ANALYTICAL METHODS

Table 3-3 identifies the DSs where existing data either do not exist or are of insufficient quality to resolve the DSs. For these DSs, Table 3-3 presents computational and/or surveying/sampling methods that could be used to obtain the required data.

Table 3-3. Information Required to Resolve the Decision Statements.[a] (2 Pages)

DS #	Remedial Investigation Variable	Required Data	Computational Methods	Survey/Analytical Methods
1 and 2	Concentrations of radiological COCs	Alpha, beta, and gamma COC concentrations in soils for evaluation against ARARs and PRGs. Location data (depth and lateral extent of COCs within waste site boundaries).	RESRAD analytical modeling method for human health dose assessment. STOMP numerical modeling package to develop models for contaminant transport through vadose zone to groundwater.	Field screening with radiological detection equipment. Geophysical borehole logging with downhole radiological detectors. Soil sampling and laboratory analysis.

Table 3-3. Information Required to Resolve the Decision Statements.[a] (2 Pages)

DS #	Remedial Investigation Variable	Required Data	Computational Methods	Survey/Analytical Methods
3	Concentrations of nonradiological COCs	Nonradiological (e.g., inorganic metals and anions, and SVOCs) COC concentrations in soils for evaluation against ARARs and PRGs. Location data (depth and lateral extent of COCs within waste site boundaries).	Risk assessment. STOMP numerical modeling package to develop models for contaminant transport through vadose zone to groundwater.	Soil sampling and laboratory analysis.
1, 2, and 3	Soil physical properties	Moisture content, bulk density, particle size distribution	Direct comparison to existing models to determine conductivity.	Soil sampling and laboratory analysis.

[a] See Table 3-5 for additional information.
SVOC = semi-volatile organic compound

Table 3-4 presents details on the computational methods identified in Table 3-3. These details include the source and/or author of the computational method and information on how the method could be applied to this study.

Table 3-4. Details on Identified Computational Methods.

DS #	Computational Method	Source/ Author	Application to Study	Satisfy Input Req't?
1 and 2	RESRAD	Argonne National Laboratory	RESRAD will be used to estimate direct human radiation exposure to account for radioactive decay.	Yes
1, 2, and 3	STOMP	Pacific Northwest National Laboratory	STOMP is a numerical modeling package for development of models that can be used to estimate the migration of radiological and nonradiological contaminants to groundwater for indirect exposure estimates.	Yes

Table 3-5 identifies each of the survey and/or analytical methods that may be used to provide the required information needed to resolve each of the DSs. The possible limitations associated with each of these methods are also provided.

Table 3-5. Potentially Appropriate Survey and/or Analytical Methods. (2 Pages)

Media	Remediation Variable	Potentially Appropriate Survey/Analytical Method	Possible Limitations
Field Screening			
Vadose zone soils	Gross and isotopic gamma emissions	Cone penetrometer; NaI or BGO detector logging	A closed-end rod is pushed into the soil to the desired depth. A small-diameter NaI or BGO detector (or other suitable detector) is used to log the gross gamma response with depth. The cone penetrometer may not be effective in cobbly or rocky soils or for deep penetration.
	Radiological and chemical field screening	Cone penetrometer and direct push sampling	A closed-end rod is pushed into the soil to the desired depth, where a removable tip is displaced and a small volume of soil is retrieved. Due to the small volume of soil retrieved, multiple samples would be required to meet sample volume requirements for a large analyte list. Cobbles, rocks, or other features in the soil column easily stop the cone penetrometer and other direct-push methods.
	Gross and isotopic gamma emissions	Direct push; NaI or BGO detector logging	A small-diameter casing is pushed into the soil to the desired depth. A small-diameter NaI or BGO detector (or other suitable detector) is used to log the gamma response with depth. Direct-push methods (e.g., GeoProbe™) may be ineffective in cobbly or rocky soils or deeper than approximately 10 m (33 ft).
	Gamma emissions from fission products, Am-241, Pu-239, and Np-237	Borehole SGL with HPGe detector	Gamma-ray logging provides the concentration profiles of gamma-emitting radionuclides such as Am-241, Pu-239, and many fission products in a borehole environment. It is considered by some to be more accurate than sampling and laboratory assay because the assay is performed in situ with less disturbance of the sample, there is higher vertical spatial resolution, and the sample size is much larger. This method may also be more economical than traditional sampling and analysis. This method does not assess radionuclides or daughter products that do not emit gamma rays. The gamma energies from Am-241, Pu-239, and Np-237 are at the low end of the spectrum, which results in high numerical minimum detectable activities and possible matrix effects from other isotopes. This technique requires the use of a single casing (installed by drilling or driving) in contact with the soil formation.
	Neutron emissions from plutonium and from alpha-neutron soil interaction	Borehole passive neutron logging	Passive neutron logging provides indication of the presence of neutron-emitting isotopes in soils. The passive neutron detection limit is approximately 100 nCi/g in TRU-contaminated soil.

Table 3-5. Potentially Appropriate Survey and/or Analytical Methods. (2 Pages)

Media	Remediation Variable	Potentially Appropriate Survey/Analytical Method	Possible Limitations
	Active neutron emissions from TRU-contaminated soil	Borehole passive/active neutron-logging methods	This technique uses source materials or generators to release neutrons into the soil formation. Passive detectors measure the response to the neutron flux as a means of detecting specific transuranic constituents. Although neutron activation methods have been developed, these methods are not expected to be useful for this initial characterization effort. At present, these techniques are too expensive and time consuming and logistical problems are associated with the handling of intense sources or generators.
	Vertical moisture profile	Borehole neutron-neutron moisture logging	N-N moisture logs can be used to determine current moisture content profiles of the subsurface through new or existing boreholes. The moisture profiles are often directly correlated to contaminant concentrations, sediment grain size, composition, or subsurface structural features. For this project, the moisture profile may be useful for helping determine the location of contamination and establish geologic conditions to support contaminant fate and transport modeling. It may also be correlated to reflections identified in ground-probing radar surveys.
Laboratory Samples			
Vadose zone soils	All COCs and physical properties	Laboratory analysis	Highly contaminated samples require use of onsite laboratories, with associated impacts (e.g., high cost, reduced analyte lists, matrix effects, degraded detection limits, and long turnaround times). Lower contamination levels allow use of offsite laboratories, avoiding these limitations. Physical property analysis will include bulk density, moisture content, and particle size distribution.

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BGO = bismuth-germinate
EMI = electromagnetic imaging
GPR = ground-penetrating radar
HPGe = high-purity germanium
NaI = sodium iodide
SGL = spectral gamma logging

3.4 ANALYTICAL PERFORMANCE REQUIREMENTS

Table 3-6 defines the analytical performance requirements for the data that need to be collected to resolve each of the DSs. These performance requirements include the PQL and the precision and accuracy requirements for each of the COCs.

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		15 mrem/yr[b] (pCi/g)	500 mrem/yr[b] (pCi/g)	GW Protection[b,c] (pCi/g)		Water[d] Low Activity (pCi/L)	Water[d] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Americium-241	14596-10-2	335	112,000	TBD	Americium isotopic – AEA	1	400	1	4,000	±20%	80-120%	±35%	65-135%
Cesium-137	10045-97-3	23.4	780	TBD	GEA	15	200	0.1	2,000	±20%	80-120%	±35%	65-135%
Cobalt-60	10198-40-0	4.90	164	TBD	GEA	25	200	0.05	2,000	±20%	80-120%	±35%	65-135%
Neptunium-237	13994-20-2	59.2	1,980	TBD	Neptunium-237 – AEA	1	N/A	1	8,000	±20%	80-120%	±35%	65-135%
Plutonium-238	13981-16-3	47	15,700	TBD	Plutonium isotopic – AEA	1	130	1	1,300	±20%	80-120%	±35%	65-135%
Plutonium-239/240	Pu-239/240	425	14,200	TBD	Plutonium isotopic – AEA	1	130	1	1,300	±20%	80-120%	±35%	65-135%
Strontium-90	Rad-Sr	2,410	80,300	TBD	Total radioactive strontium – GPC	2	80	1	800	±20%	80-120%	±35%	65-135%
Technetium-99	14133-76-7	412,000	13,700,000	TBD	Technetium-99 – liquid scintillation	15	400	15	4,000	±20%	80-120%	±35%	65-135%
Thorium-232	TH-232	4.8	160	TBD	Thorium isotopic – AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	80-120%	±35%	65-135%
Tritium (H-3)	10028-17-8	66,900	2,230,000	TBD	Tritium – liquid scintillation	400	400	400	400	±20%	80-120%	±35%	65-135%
Uranium-234	13966-29-5	2,660	88,800	TBD	Uranium isotopic – AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	80-120%	±35%	65-135%
Uranium-235	15117-96-1	101	3,370	TBD	Uranium isotopic – AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	80-120%	±35%	65-135%
Uranium-238	U-238	504	16,800	TBD	Uranium isotopic – AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	80-120%	±35%	65-135%

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[a] (mg/kg)	Method C[c] (mg/kg)	GW Protection[d] (mg/kg)		Water[d] Low Activity (pCi/L)	Water[d] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Metals													
Arsenic	7440-38-2	1.67	219	0.00583	Metals – 6010 – ICP	0.1	0.2	10	20	[h]	[h]	[h]	[h]
					Metals – 6010[b] – ICP (trace)	0.01	N/A	1	N/A	[h]	[h]	[h]	[h]
Cadmium	7440-43-9	80	3,500	0.5[i]	Metals – 6010 – ICP	0.005	0.01	0.5	1	[h]	[h]	[h]	[h]
					Metals – 6010[j] – ICP (trace)	0.005	N/A	0.5	N/A	[h]	[h]	[h]	[h]
Chromium (total)	7440-47-3	80,000[k]	3.5E6[k]	10[l]	Metals – 6010 – ICP	0.01	0.01	1	2	[h]	[h]	[h]	[h]
					Metals – 6010 – ICP (trace)	0.01	N/A	1	N/A	[h]	[h]	[h]	[h]
Chromium VI	18540-29-9	400	17,500	8	Chromium (hex) – 7196 – colorimetric	0.01	4	0.5	200	[h]	[h]	[h]	[h]
Copper	7440-50-8	2,960	130,000	59.2	Metals – 6010 – ICP	0.025	0.025	2.5	2.5	[h]	[h]	[h]	[h]
Lead	7439-92-1	353[f]	1,000[m]	1.5[n]	Metals – 6010 – ICP	0.1	0.2	10	20	[h]	[h]	[h]	[h]
					Metals – 6010 – ICP(trace)	0.01	N/A	1	N/A	[h]	[h]	[h]	[h]
Mercury	7439-97-6	24	1,050	0.2[i]	Mercury - 7470 – CVAA	0.0005	0.005	N/A	N/A	[h]	[h]	[h]	[h]
					Mercury - 7471 – CVAA	N/A	N/A	0.2	0.2	[h]	[h]	[h]	[h]
Nickel	7440-02-0	1,600[o]	70,000[o]	32	Metals – 6010 – ICP	0.04	0.04	4	4	[h]	[h]	[h]	[h]
Selenium	7782-49-2	400	17,500	5[p]	Metals - 6010 – ICP	0.1	0.2	10	20	[q]	[q]	[q]	[q]
Silver	7440-22-4	400	17,500	8	Metals – 6010 – ICP	0.02	0.02	2	2	[h]	[h]	[h]	[h]
					Metals – 6010 – ICP (trace)	0.005	N/A	0.5	N/A	[h]	[h]	[h]	[h]
Uranium (total)	7440-61-1	240[o]	10,500[o]	2[p]	Uranium total – kinetic phosphorescence analysis	0.0001	0.02	1	0.2	±20%	80-120%	±35%	65-135%
Inorganics													
Ammonia/ ammonium	7664-41-7	Unlimited	Unlimited	27,200	Ammonia – 350.N[o]	0.05	800	0.5	8,000	[h]	[h]	[h]	[h]

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (5 Page)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[b] (mg/kg)	Method C[c] (mg/kg)	GW Protection[d] (mg/kg)		Water[e] Low Activity (pCi/L)	Water[f] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Chloride	16887-00-6	25,000[g]	25,000[g]	25,000	Anions – 9056 – IC	0.2	5	2	5	*	*	*	*
Fluoride	16984-48-8	4,800	210,000	96	Anions – 9056 – IC	0.5	5	5	5	*	*	*	*
Nitrate	14797-55-8	128,000	Unlimited	4,400	Anions – 9056 – IC	0.25	10	2.5	40	*	*	*	*
Nitrite	14797-65-0	8,000	350,000	160	Anions – 9056 – IC	0.25	15	2.5	20	*	*	*	*
Nitrate/nitrite	NO_3/NO_2-N	128,000	Unlimited	4,400	NO_3/NO_2 – 350.J[h]	0.075	5	0.75	10	*	*	*	*
Phosphate	14265-44-2	N/A	N/A	None	Anions – 9056 – IC	0.5	15	5	40	*	*	*	*
Sulfate	14808-79-8	25,000[g]	25,000[g]	25,000[g]	Anions – 9056 – IC	0.5	15	5	40	*	*	*	*
Organics													
1,1-dichloroethane	75-34-3	8,000	330,000	80	Volatile organics – 8260 – GC/MS	0.01	0.01	0.01	0.01	*	*	*	*
1,2-dichloroethane	107-06-2	11	1,440	0.0481	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
1,1,1-trichloroethane	71-55-6	72,000	2,130,000	720	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
2-propanone (acetone)	67-64-1	8,000	350,000	80	Volatile organics – 8260 – GC/MS	0.02	0.02	0.02	0.02	*	*	*	*
Benzene	71-43-2	34.5	4,530	0.151	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
Carbon tetrachloride	56-23-5	7.69	1,010	0.0337	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
Chlorobenzene	108-90-7	1,600	7,000	16	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
Chloroform	67-66-3	164	21,500	0.717	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
Ethyl benzene	100-41-4	8,000	350,000	80	Volatile organics – 8260 – GC/MS	0.005	0.005	0.005	0.005	*	*	*	*
Hydraulic fluids (grease)	8008-20-6	200[g]	200[g]	200[g]	Oil and grease (total recoverable) – 413.N	2	N/A	200	N/A	*	*	*	*

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[b] (mg/kg)	Method C[c] (mg/kg)	GW Protection[d] (mg/kg)		Water[d] Low Activity (pCi/L)	Water[d] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
2-butanone (MEK)	78-93-3	48,000	2,100,000	480	Volatile organics – 8260 – GCMS	0.01	0.01	0.01	0.01	[h]	[h]	[h]	[h]
Methyl iso butyl ketone (MIBK)	108-10-1	6,400	280,000	64	Volatile organics – 8260 – GCMS	0.01	0.01	0.01	0.01	[h]	[h]	[h]	[h]
Dichloromethane (methylene chloride)	75-09-2	133	17,500	0.583	Volatile Organics – 8260 – GCMS	0.005	0.005	0.005	0.005	[h]	[h]	[h]	[h]
n-butyl benzene	104-51-8	VOA TIC	VOA TIC	N/A	Volatile Organics – 8260 – GCMS	0.005	N/A	0.005	N/A	N/A	N/A	N/A	N/A
Toluene	108-88-3	16,000	70,000	160	Volatile organics – 8260 – GCMS	0.005	0.005	0.005	0.005	[h]	[h]	[h]	[h]
Tetrachloroethylene	127-18-4	19.6	2,570	0.0858	Volatile organics – 8260 – GCMS	0.005	0.005	0.005	0.005	[h]	[h]	[h]	[h]
Cis/trans-1,2-dichloro ethylene	156-60-5	1,600	70,000	16	Volatile organics – 8260 – GCMS	0.005	0.005	0.005	0.005	[h]	[h]	[h]	[h]
Trichloroethylene	79-01-6	90.9	11,900	0.398	Volatile organics – 8260 – GCMS	0.005	0.005	0.005	0.005	[h]	[h]	[h]	[h]
Xylene (total)	1330-20-7	160,000	7,000,000	1,600	Volatile organics – 8260 – GCMS	0.005	0.005	0.005	0.005	[h]	[h]	[h]	[h]
Normal paraffin hydrocarbons	8008-20-6	200[m]	200[m]	200[m]	Non-halogenated VOA – 8015M – GC modified for hydrocarbons	0.5	0.5	5	5	[h]	[h]	[h]	[h]
Phenol	108-95-2	48,000	2,100,000	960	Semi-volatiles – 8270 – GCMS	0.01	0.1	0.33	3.3	[h]	[h]	[h]	[h]
PCBs	1336-36-3	0.13	5.19	0.00114[n]	PCBs – 8082 – GC	0.0005	0.005	0.0165	0.1	[h]	[h]	[h]	[h]
TBP	126-73-8	None	None	None	Semi-volatiles – 8270 – GCMS	0.1	0.5	3.3	5	[h]	[h]	[h]	[h]
Total organic carbon	TOC	N/A	N/A	None	TOC – 9060- combustion	1	1	100	100	±20%	80-120%	±35%	65-135%
Field Screening Measurements													
PH	TBD	TBD	TBD	TBD	TBD	TBD		TBD		TBD	TBD	TBD	TBD

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (5 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[b] (mg/kg)	Method C[c] (mg/kg)	GW Protection[d] (mg/kg)		Water[f] Low Activity (pCi/L)	Water[f] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Soil Physical Properties													
Moisture content	N/A	N/A	N/A	N/A	D2216	N/A		wt%		N/A	N/A	N/A	N/A
Particle size distribution	N/A	N/A	N/A	N/A	D422	N/A		wt%		N/A	N/A	N/A	N/A
Lithology	N/A	N/A	N/A	N/A	BHI-EE-01, Procedure 7.0	N/A		Descriptive		N/A	N/A	N/A	N/A

[a] The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the FS, will be finalized in the ROD, and will drive remediation of the site.

[b] 15 mrem/yr – rural residential, 300 mrem/yr – commercial industrial, GW = groundwater protection radionuclide values from the Washington State Department of Health's (WDOH's) *Hanford Guidance for Radiological Cleanup* (WDOH 1993). Radionuclide values are calculated using parameters from WDOH guidance.

[c] The "100 times groundwater" rule does not apply to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using STOMP code modeling (PNNL 2000).

[d] Water values for sampling quality control (e.g., equipment blanks/rinses) or drainable liquid (if recovered).

[e] MTCA Method B soil values for direct exposure.

[f] MTCA Method C industrial soil values for direct exposure.

[g] MTCA Method B soil values for groundwater protection.

[h] Precision and accuracy requirements are identified and defined in the referenced EPA procedures.

[i] Based on the Federal primary drinking water standards (40 CFR 141).

[j] All four-digit numbers refer to *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA 1986).

[k] Value based upon calculations (III) MTCA soil concentrations.

[l] Based on EPA's *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children* (EPA 1994b).

[m] Based upon MTCA Method A values.

[n] Based on 100 times the *National Primary Drinking Water Regulations* action level (40 CFR 141).

[o] Value based upon nickel or uranium soluble salts value.

[p] Based on a proposed drinking water standard.

[q] From *Methods of Analysis of Water and Waste* (EPA 1983).

AEA = alpha energy analysis
CAS = Chemical Abstract Service
CVAA = cold vapor atomic absorption
GC = gas chromatograph
GC/MS = gas chromatograph/mass spectrometry
GPC = gas proportional counter
IC = ion chromatography
ICP/MS = inductively coupled plasma mass spectrometer
N/A = not applicable
TBD = to be determined
TOC = total organic carbon

4.0 STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

4.1 OBJECTIVE

The primary objective of DQO Step 4 is for the DQO team to identify the spatial, temporal, and practical constraints on the sampling design and to consider the consequences. This objective (in terms of the spatial, temporal, and practical constraints) ensures that the sampling design results in the collection of data that accurately reflect the true condition of the site and/or populations being studied.

4.2 WORKSHEETS FOR STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

Table 4-1 defines the population of interest to clarify what the samples are intended to represent. The characteristics that define the population of interest are also identified.

Table 4-1. Characteristics that Define the Population of Interest.

DS #	Population of Interest	Characteristics
Cribs and Specific Retention Trenches		
1, 2, and 3	The set of all environmental samples within the vadose zone associated with the representative waste sites	Concentrations and activities of transuranic radionuclides, other radionuclides, metals, anions, and limited VOA and semi-VOA organic constituents; physical properties including moisture content, bulk density, lithology, and grain-size distribution.

Table 4-2 defines the spatial boundaries of the decision and the domain or geographic area (or volume) within which all decisions must apply (in some cases, this may be defined by the OU). The domain is a region distinctly marked by some physical features (i.e., volume, length, width, and boundary).

Table 4-2. Geographic Boundaries of the Investigation.

DS #	Geographic Boundaries of the Investigation
1, 2, and 3	The geographic boundaries for the investigation are the boundaries of the individual representative waste sites from the surface to groundwater.

When appropriate, the population is divided into strata that have relatively homogeneous characteristics. The DQO team must systematically evaluate process knowledge, historical data, and plant configurations to present evidence of logic that supports alignment of the population into strata with homogeneous characteristics. Table 4-3 identifies the strata with homogeneous characteristics.

Table 4-3. Strata with Homogeneous Characteristics. (2 Pages)

DS #	Population of Interest	Strata	Homogeneous Characteristic Logic
216-Z-1A Tile Field			
1, 2, and 3	The set of all environmental samples within the vadose zone associated with the representative waste sites	Overburden over the contaminated tile field (depth varies)	Soils that are not expected to be contaminated as a result of liquid discharges to the tile field. Note that this stratum is not significant from an RI/FS decision-making standpoint and will not be carried further in this study.
1, 2, and 3		Highest contaminant concentration layer (presumed to be 17 m [58 ft])	Particulates and high distribution coefficient contaminants were sorbed and/or filtered out of the liquid flow via the soils at the bottom of the excavated field. This zone is expected to contain the highest concentrations of contaminants and to have decreasing concentrations with depth. May also contain residual concentrations of mobile constituents.
2 and 3		Low contaminant concentration layer (presumed to extend from 17 m to 63 m [58 ft to 207 ft])	This zone is expected to contain low concentrations of mobile contaminants from the source to the groundwater table. Concentrations are expected to remain fairly constant through the impacted zone because the majority of the contaminants have been flushed through the system, leaving residual concentrations.
216-Z-9 Trench			
1, 2, and 3	The set of all environmental samples within the vadose zone associated with the representative waste sites	Highest contaminant concentration layer (presumed to be 32 m [105 ft])	Particulates and high distribution coefficient contaminants were sorbed and/or filtered out of the liquid flow via the soils at the bottom of the excavated trench. This zone is expected to contain the highest concentrations of contaminants and to have decreasing concentrations with depth. May also contain residual concentrations of mobile constituents.
2 and 3		Moderate to low contaminant concentration layer[a] (presumed to extend from 32 m to 37 m [105 ft to 121 ft])	A moderate concentration layer was formed immediately beneath the expected high concentration layer. In this zone, finer particulates and moderate distribution coefficient contaminants from the liquid waste streams were filtered and sorbed. High volumes of disposed liquids may have carried some immobile constituents into this zone, and residual concentrations of mobile constituents may also be present.

Table 4-3. Strata with Homogeneous Characteristics. (2 Pages)

DS #	Population of Interest	Strata	Homogeneous Characteristic Logic
			This zone is expected to have decreasing concentrations with depth as more immobile constituents filter and sorb out with the passing of the moisture front. However, concentration changes are not strictly depth-related. The Pu and CCl_4 appear to be associated with the fine grained layers. Also, the vapor vacuum extraction system has removed more of the VOCs from the high permeability layers.[a]
2 and 3		Low contaminant concentration layer (presumed to extend from 37 m to 67 m [121 ft to 220 ft])	This zone is expected to contain low concentrations of mobile contaminants from the source to the groundwater table. Concentrations are expected to remain fairly constant through the impacted zone because the majority of the contaminants have been flushed through the system, leaving residual concentrations.

[a] The wetted front may have reached groundwater for trench site. It is not known if groundwater was impacted by the discharges in the tile field site.
VOC = volatile organic compound

The temporal boundaries of the decision are defined in Table 4-4.

Table 4-4. Temporal Boundaries of the Investigation.

DS #	Timeframe	When to Collect Data
Field Screening		
1, 2, and 3	N/A	If possible, avoid extreme hot/cold months and inclement weather that that could potentially affect sampling operations and sample contaminant concentrations during collection and handling.
Laboratory Samples		
1, 2, and 3	N/A	If possible, avoid extreme hot/cold months and inclement weather that that could potentially affect sampling operations and sample contaminant concentrations during collection and handling.

N/A = not applicable

4.3 SCALE OF DECISION MAKING

Table 4-5 defines the scale of decision making for each DS. The scale of decision making is defined as the smallest, most appropriate subsets of the population (sub-population) for which decisions will be made based on the spatial or temporal boundaries of the area under investigation.

Table 4-5. Scale of Decision Making.

DS #	Population of Interest	Geographic Boundary	Temporal Boundary		Strata
			Timeframe	When to Collect Data	
1, 2, and 3	The set of all environmental samples within the vadose zone associated with the representative waste sites	Boundaries of the individual representative waste sites from the surface to groundwater	N/A	If possible, avoid extreme hot/cold months and inclement weather that that could potentially affect sampling operations and sample contaminant concentrations during collection and handling.	Highest contaminant concentration layer
					Moderate-to-low contaminant concentration layer[a]
					Low contaminant concentration layer

[a] This layer applies uniquely to the 216-Z-9 Trench, as shown in Table 4-3.
N/A = not applicable

4.4 PRACTICAL CONSTRAINTS

Table 4-6 identifies the practical constraints that may impact the data collection effort. These constraints include physical barriers, difficult sample matrices, high radiation areas, or any other condition that will need to be taken into consideration in the design and scheduling of the sampling program.

Table 4-6. Practical Constraints on Data Collection. (2 Pages)

Significant contamination concentrations are present in both representative waste sites. Contamination controls will limit and hinder drilling and sample collection operations.
The 216-Z-9 Trench is not accessible for conventional vertical drilling equipment. The limitations imposed by the enclosure structure are identified as a project technical issue in Section 1.5.2 and are described in Section 1.6.1. This is discussed in greater detail in Section 7.4.1.

Table 4-6. Practical Constraints on Data Collection. (2 Pages)

Borehole soil sampling equipment may not obtain sufficient volumes of sample media if the sampled zone is 0.6 m (2 ft) thick or less. Advancement of the borehole casing may drag contamination down the hole. Drilling operations may volatilize the VOAs (including carbon tetrachloride) that are present. Thus, an inaccurate measurement may be obtained.
The soils in the vadose zone may include cemented zones that could pose difficulties in sample collection.
Health and safety constraints may be imposed during characterization sampling to ensure that as low as reasonably achievable issues are properly addressed when sampling potentially TRU-contaminated, greater than Class C, and other radiologically contaminated soils.
Laboratory constraints are expected when analyzing soil samples with high contaminant concentrations. Soil samples in this category would be analyzed in an onsite laboratory. Impacts are expected in cost, degradation of detection limits, and possible reduction in the analyte lists. If analytical turnaround times are extended, the short hold times for certain organic constituents may be exceeded. In addition, soil physical property testing may not be possible in onsite laboratories.
Extreme weather conditions may limit or shut down field screening operations.

5.0 STEP 5 – DEVELOP A DECISION RULE

The purpose of DQO Step 5 is initially to define the statistical parameter of interest (i.e., maximum, mean, or 95% upper confidence level [UCL]) that will be used for comparison to the action level. The statistical parameter of interest specifies the characteristic or attribute that a decision maker would like to know about the population. The preliminary action level for each of the COCs is also identified in DQO Step 5. When this is established, a decision rule (DR) is developed for each DS in the form of an "IF...THEN..." statement that incorporates the parameter of interest, the scale of decision making, the preliminary action level, and the AAs that would result from resolution of the decision. Note that the scale of decision making and AAs were identified earlier in DQO Steps 4 and 2, respectively.

5.1 INPUTS NEEDED TO DEVELOP DECISION RULES

Tables 5-1, 5-2, and 5-3 present the information needed to formulate the DRs that are presented in Section 5.2. This information includes the DSs and AAs identified in DQO Step 2, the scale of decision making identified in DQO Step 4, and the statistical parameters of interest and preliminary action levels for each of the COCs.

Table 5-1. Decision Statements.

DS #	Decision Statement
1	Determine whether the contaminant concentrations are TRU or greater than Class C and evaluate special remedial alternatives in a FS, or evaluate conventional remedial alternatives in a FS.
2	Determine whether the soil is radiologically contaminated and evaluate remedial alternatives in a FS or evaluate the site for closure with no remedial action.
3	Determine whether the soil is chemically contaminated and evaluate remedial alternatives in a FS or evaluate the site for closure with no remedial action.

Table 5-2. Inputs Needed to Develop Decision Rules. (2 Pages)

DS #	COCs	Parameter of Interest	Scale of Decision Making	Preliminary Action Levels
1	Transuranic radionuclides	Soil sampling; maximum detected values	Vadose zone soils	100 nCi/g
	Greater than Class C radionuclides			>100 nCi/g[a]
2	Radionuclides			RESRAD lookup values and TBD through other modeling; radionuclide concentrations equating to dose limits from 15 to 500 mrem/yr above background

Table 5-2. Inputs Needed to Develop Decision Rules. (2 Pages)

DS #	COCs	Parameter of Interest	Scale of Decision Making	Preliminary Action Levels
3	Nonradiological constituents	Soil sampling; maximum detected values	Vadose zone soils	MTCA and other regulatory levels (identified in Table 3-6)
2 and 3	Soil physical properties			N/A

[a] This limit applies to alpha emitting radionuclides with half-lives over 5 years in accordance with 10 CFR 61.55.
N/A = not applicable
TBD = to be determined

The AAs identified in DQO Step 2 are summarized in Table 5-3.

Table 5-3. Alternative Actions.

PSQ #	AA #	Alternative Actions
1	1	Evaluate special remedial alternatives in a FS.
	2	Evaluate conventional remedial alternatives in a FS.
2	1	Evaluate remedial alternatives in a FS.
	2	Evaluate the site for closure with no remedial action.
3	1	Evaluate remedial alternatives in a FS.
	2	Evaluate the site for closure with no remedial action.

5.2 DECISION RULES

The output of DQO Step 5 and the previous DQO steps are combined into "IF...THEN" DRs that incorporate the parameter of interest, the scale of decision making, the action level, and the actions that would result from resolution of the decision. The DRs are listed in Table 5-4.

Table 5-4. Decision Rules. (2 Pages)

DR #	Decision Rule
1	If the true maximum (as estimated by the maximum detected sample values) activity of transuranic radionuclides within the soil samples in each of the applicable strata[a] is greater than or equal to 100 nCi/g or the greater than Class C definition, evaluate special remedial alternatives in a FS; otherwise, evaluate conventional remedial alternatives in a FS.

Table 5-4. Decision Rules. (2 Pages)

DR #	Decision Rule
2	If the true maximum (as estimated by the maximum detected sample values) activity of radionuclides within the soil samples in each of the applicable strata[a] results in a radiological dose greater than or equal to 15 to 500 mrem/yr above background, evaluate remedial alternatives in a FS; otherwise, evaluate the site for closure with no remedial action.
3	If the true maximum (as estimated by the maximum detected sample values) concentration of chemical constituents within the soil samples in each of the applicable strata[a] is greater than or equal to the preliminary action levels in Table 3-6, evaluate remedial alternatives in a FS; otherwise, evaluate the site for closure with no remedial action.

[a] The applicable strata include the highest contaminant concentration layer (216-Z-1A and 216-Z-9), the moderate-to-low contaminant concentration layer (216-Z-9 only), and the low contaminant concentration layer (216-Z-1A and 216-Z-9).

Step 5 – Develop a Decision Rule

6.0 STEP 6 – SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

Because analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). For this reason, the primary objective of DQO Step 6 is to determine which DSs (if any) require a statistically based sample design. For those DSs requiring a statistically based sample design, DQO Step 6 defines tolerable limits on the probability of making a decision error.

6.1 STATISTICAL VERSUS NON-STATISTICAL SAMPLING DESIGN

Table 6-1 provides a summary of the information used to support the selection between a statistical versus a non-statistical sampling design for each DS. The factors that were taken into consideration in making this selection included the timeframe over which each DS applies, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required.

Table 6-1. Statistical Versus Non-Statistical Sampling Design.

DS #	Time-frame (Years)	Qualitative Consequences of Inadequate Sampling Design (Low/Moderate/Severe)	Resampling Access After Remedial Investigation (Accessible/Inaccessible)	Proposed Sampling Design (Statistical/ Non-Statistical)
1, 2, and 3[a]	N/A	Low	Accessible	Non-statistical
1, 2, and 3[a]	N/A	Severe	Accessible	Statistical

[a] As shown in Table 2-1, AAs 1-1, 2-1, and 3-1 have low consequences of error; AAs 1-2, 2-2, and 3-2 have severe consequences of error.
N/A = not applicable

The second row of Table 6-1 indicates that a statistical sampling design would be proposed for this DQO process because of the severe consequences of an inadequate sampling design. This assessment is based on strict adherence to the DQO process without considering the status of the 200-PW-1 OU representative waste sites. The contamination status of these sites is well documented and they are known to contain TRU-contaminated, radiologically contaminated, and chemically contaminated soils. There is no risk that these sites will be erroneously categorized or considered for no action remediation alternatives. Therefore, AAs 1-1, 2-1, and 3-1 (Table 2-1) associated with the "severe" error consequence do not apply. The "low" severity consequence associated with AAs 1-1, 2-1, and 3-1 (Table 2-1) will be used to determine the sampling design requirements. The proposed sampling design is, therefore, judgmental (as indicated in the first row of Table 6-1).

6.2 NON-STATISTICAL DESIGNS

A biased (or focused) sampling approach that targets the maximum potential contamination within a waste site is considered appropriate for the waste sites in the 200-PW-1 OU. Contaminant distributions are expected to follow relatively predictable patterns based on process knowledge and historical data.

For the DSs to be resolved using a non-statistical design, there is no need to define the "gray region" or the tolerable limits on decision error because these only apply to statistical designs. The nature of the waste sites to be investigated in the RI supports the use of focused sampling, as identified in *Washington State Department of Ecology Toxics Cleanup Program Guidance on Sampling and Data Analysis Methods* (Ecology 1995). This guidance document defines "focused sampling" as selective sampling of areas where potential or suspected soil contamination can reliably be expected to be found if a release of a hazardous substance has occurred. The trench and tile field structures to be investigated had released contaminants in a point-source or line-source manner. The contaminants that were released in such a manner have been shown to impact the soil immediately beneath the waste site with minimal lateral spread (Smith 1973 and PNNL 1998). Therefore, focusing the RI sampling throughout the site will ensure sample collection in the area of greatest impact associated with the discharge.

7.0 STEP 7 – OPTIMIZE THE DESIGN

7.1 PURPOSE

The purpose of DQO Step 7 is to identify the most resource-effective design for generating data to support decisions while maintaining the desired degree of precision and accuracy. When determining an optimal design, the following activities should be performed:

- Review the DQO outputs from the previous DQO steps and the existing environmental data.
- Develop general data collection design alternatives.
- Select the sampling design (e.g., techniques, locations, or numbers/volumes) that most cost effectively satisfies the project's goals.
- Document the operational details and theoretical assumptions of the selected design.

7.2 WORKSHEETS FOR STEP 7 – OPTIMIZE THE DESIGN

Table 7-1 identifies information in relation to determining the data collection design.

Table 7-1. Determine Data Collection Design.

DS #	Statistical	Non-Statistical	Rationale
1, 2, and 3	N/A	Non-statistical sampling design	Judgmental data collection design is applicable to investigation as preliminary data suggest that the highest levels of contamination are located relative to release points or the bottom of waste sites. Relative size of waste sites presents a point-source-type disposal, focusing the area of investigation on the distribution of contaminants with depth. Consequences of erroneous decisions are not severe. Characterization sampling results will be verified by confirmatory sampling of analogous sites during the confirmatory and remedial design phase.

N/A = not applicable

Table 7-2 is used to develop general data collection design alternatives. If the data collection design for a given decision will be non-statistical, determine what type of non-statistical design is appropriate (i.e., haphazard or judgmental).

Table 7-2. Determine Non-Statistical Sampling Design.

DR #	Haphazard	Judgmental
1, 2, and 3	None	Professional judgmental sampling design is indicated.

The data collection design alternatives for this project are described in Table 7-3.

Table 7-3. Methods for Collection of Data at Depth. (2 Pages)

Method	Description
Trenching or test pit sampling	Excavation with backhoe or excavator. This technique provides grab samples taken directly from the soil column (approximate 0.3-m [1-ft] intervals) or from the excavator bucket. Because this technique creates a trench, direct inspection of the exposed soil column is possible. This method is not well suited for soils contaminated with alpha-emitting radionuclides because of the potential for spread of contamination at levels that cannot be readily detected with hand held survey instruments.
Cone penetrometer or direct-push sampling	A closed-end rod is pushed into the soil to the desired depth where a removable tip is displaced and a small volume of soil is retrieved. Due to the small volume of soil retrieved, multiple samples would be required to meet sample volume requirements for a large analyte list. Cobbles, rocks, or other features in the soil column easily stop the cone penetrometer and other direct-push methods. The resulting hole can be geophysically logged, providing information on gamma-emitting radionuclides and moisture content.
Auger drilling and sampling	Grab samples may be collected from the auger fitting during drilling, or split tube samples may be collected with the aid of hollow-stem auger "flights." To achieve laboratory analysis sample volume needs for large analytical lists, a 0.6-m (2-ft) core sample from a 13-cm (5-in.)-diameter sampler is typically needed. Running a sample tube down the hollow center of the flight retrieves split tube samples. This method is not well suited for drilling in soils contaminated with alpha-emitting radionuclides because of contamination control limitations. The auger split-spoon samples are typically 6 cm (2.5 in.) in diameter.
Cable tool drilling and sampling	This slow drilling method is particularly useful in highly contaminated areas because potential contamination releases can be more easily controlled. This drilling method allows collection of grab samples from the drive barrel or split-spoon. To achieve adequate laboratory analysis sample volumes for large analytical lists, a 0.6-m (2-ft)-long core sample from a 13-cm (5-in.)-diameter sampler is typically needed. DOE-owned, controlled cable tool rigs are available onsite for use in highly contaminated areas. In alpha-contaminated soils, significant contamination controls are required.
Diesel hammer drilling	The diesel hammer is a dual-string, reverse-air-circulation drilling method. The potential impacts of this drilling method include degraded sample quality and increased contaminant release potential. Because of the introduction of air to the sample media, affects on analytical results for volatile organics and increased potential for dust result from this technique.

Table 7-3. Methods for Collection of Data at Depth. (2 Pages)

Method	Description
Sonic drilling and sampling	Sonic drilling can quickly advance either well casings or sample tubes. Samples are retrieved similar to split-spoon sample collection during a cable tool operation. To achieve adequate laboratory analysis sample volumes, a 0.6-m (2-ft)-long core sample is typically needed from a 13-cm (5-in.)-diameter sampler. Sonic drilling is much faster than cable tool drilling but the technique generates a significant amount of heat, which can alter samples (e.g., liberate volatile organics from the sampled soils) and the surrounding formation. In alpha-contaminated soils, significant contamination controls are required and may be difficult to implement because of the nature of the equipment and operations.
Air rotary drilling and sampling	Air rotary drilling is much faster than other drilling techniques. Grab samples and split-spoon samples may be taken using this method. In addition, most rotary drill rigs can be configured to collect core samples. To achieve adequate laboratory analysis sample volumes, a 0.6-m (2-ft)-long core sample is typically needed from a 13-cm (5-in.)-diameter sampler. This technique may introduce air into the soil, potentially altering the sample quality and formation moisture levels.
Pile driver direct-push sampling	A pile driver set upon drive casing can be used with or without a liner to collect soil samples until refusal depth is reached. The use of crane and pile driver allows drive casing to be pushed into the soil formation at a stand-off distance from the drilling location.

The design options are evaluated based on cost and ability to meet the DQO constraints. The results of the trade-off analyses should lead to one of two outcomes: (1) the selection of a design that most efficiently meets all of the DQO constraints, or (2) the modification of one or more outputs from DQO Steps 1 through 6 and the selection of a design that meets the new constraints.

The key features of the selected design are then documented, including (for example) the following:

- Descriptions of sample locations, strata, inaccessible areas, and maps (if beneficial)
- Directions for selecting sample locations (if the selection is not necessary or appropriate at this time)
- Order in which samples should be collected (if important)
- Stopping rules
- Special sample collection methods
- Special analytical methods.

7.3 SAMPLING OBJECTIVES

In Section 3.2.1, it was concluded that the identified radionuclide and the chemical constituent data gaps must be filled to support evaluation of the engineered multimedia barrier alternative. Table 7-4 summarizes the characterization goals and drivers for the 200-PW-1 OU sampling designs.

Table 7-4. Characterization Goals and Drivers.

Characterization Goals	Waste Site	Sampling Area	Driver
Determine the types and concentrations of radiological and chemical constituents with depth at worst-case locations	216-Z-9 Trench, 216-Z-1A Tile Field	Vadose zone under the waste site footprint	Support evaluation of all remedial alternatives in the RI/FS process
Geophysically log available boreholes			Low-cost expansion of the radiological database
Analyze soils for physical properties			Support RI/FS modeling efforts

7.4 SAMPLING DESIGN

7.4.1 Preferred Sampling Design

The most cost-effective sampling design for most RI/FS-type DQO projects is one that follows the "focused sampling" methodology (Ecology 1995). This methodology applies when contamination can be reliably expected to be found if a release of a hazardous substance has occurred. This approach is viable only if reliable information can be used to focus sampling efforts on the appropriate locations. This is clearly the case for the two 200-PW-1 OU representative waste sites. The locations of the sites are well known, and there is a significant historical database that can be used to guide sampling efforts to locations with the highest contaminant concentrations.

Three sampling alternatives were initially developed for the 216-Z-1A Tile Field. The first alternative was for drilling through the worst-case contamination location in the tile field, from the surface to the groundwater. The second alternative evaluated the possible extension of borehole 299-W18-174 from the 39.7-m (130-ft) elevation to groundwater as a lower-cost alternative. However, a review of the as-built drawing for the borehole revealed that the diameter of borehole 299-W18-174 is 10.2 cm (4 in.), which is too small for borehole extension. Therefore, two sampling design alternatives are proposed for the 216-Z-1A Tile Field.

The 216-Z-9 Trench is an engineered structure with an enclosure made of steel framework and concrete roof panels. The enclosure structure is not designed to support loads greater than the weight of a few occupational workers. Because of the high plutonium and americium

concentrations in the trench, an accidental collapse of the enclosure structure would be unacceptable from a worker risk and contamination-control standpoint; therefore, special drilling alternatives are identified for this site. The sample design alternatives are presented in Table 7-5 and are evaluated in Section 7.4.2.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-Z-1A Tile Field Alternative 1 – Borehole Drilling in Vicinity of Well 299-W18-159		
Borehole characterization	Install one vadose borehole in close proximity to the 299-W18-159 borehole, which is near the center of the tile field. Refer to Figures 7-1 and 7-2. Soil samples will be collected in specific strata at the following intervals:	The 299-W18-159 borehole spectral gamma logging results indicate that the soils in the vicinity of this borehole have higher contamination levels than any other borehole that was logged. The borehole will be drilled from the surface to the water table for borehole soil sampling.
	• Highest contaminant concentration layer (H_1): – Collect one sample at 3.7 m (12 ft). – Collect one sample at the onset of native soils beneath the tile field gravel bed, presumed to be at 7.6 m (25 ft). – Collect samples at 10.7 m and 13.7 m (35 ft and 45 ft).	The radiological contamination concentrations in this region are above the TRU definition (PNNL 1998). The 3.7-m (12-ft) sample is within the sand layer of the most highly contaminated region of the tile field (PNNL 1999b). The sand is more likely to yield a sample than the gravel layer beneath it. The 7.6-m (25-ft) region is expected to contain TRU-contaminated soils, but at significantly lower concentrations than the 3.7-m (12-ft) depth. The two deeper samples will complete a vertical contaminant concentration profile within this highly contaminated layer. None of the samples collected within the H_1 layer will be analyzed for radiological COCs because there is no radiological data gap in this depth interval.
	• Low contaminant concentration sand layer (H_2): – Collect one sample at the onset of this formation, presumed to be 17 m (58 ft).	Historical data show TRU contamination to a depth of approximately 17.7 m (58 ft). This region is expected to delineate the shift to low radiological concentrations. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	• Low contaminant concentration gravel layer (H_3): – Collect one sample at the onset of this formation, presumed to be 26.5 m (87 ft).	One sample in this layer will be used to determine the concentration changes from the H_2 layer above. The sample will be analyzed for all COCs.
	• Low contaminant concentration Plio-pleistocene layer: – Collect one sample at the onset of this formation, presumed to be 37.2 m (122 ft).	The sample in this layer will be used to determine the changes from the H_3 layer above. The sample will therefore be analyzed for all COCs.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample at the onset of this formation, presumed to be 47 m (138 ft).	The Ringold E Formation consists of gravels and sand. The sample in this layer will be used to determine the changes from the Plio-pleistocene layer above. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample just above the water table (approximately 63 m [207 ft]).	One sample will be used to determine the concentrations just above the water table. The sample will be analyzed for all COCs.
	– Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples. Specific intervals to be defined in SAP.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support modeling.
Borehole geophysical logging	Geophysically log the borehole.	Log the vertical distribution of radiological contaminants to confirm analytical data and refine preliminary conceptual contaminant distribution model.
		Perform neutron moisture logging to support contaminant transport modeling.
216-Z-1A Tile Field Alternative II – No Further Characterization Alternative		
No action	Determine whether the existing characterization data identifies the TRU and greater than Class C decision as the RI/FS decision-making risk driver.	Avoid unnecessary cost and worker exposure for collection of soil samples.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-Z-9 Trench Alternative III – Conventional Drilling Through the Trench		
Borehole characterization	Stabilize the soils atop the 216-Z-9 Trench by pumping shotcrete through the vent risers in the trench roof. Spray fixative coating over all internal surfaces within the enclosure. Dismantle and dispose the enclosure structure. Install a soil ramp over the trench to provide access for conventional drilling through the trench. Figure 7-3 shows a plan view of the 216-Z-9 Trench. Figure 7-4 shows section views of the 216-Z-9 Trench and enclosure structure.	The concrete roof structure above the 216-Z-9 Trench prevents direct access for drilling. To obtain access, the concrete roof structure must be removed and a soil ramp installed into trench to give access to conventional drilling equipment. To support this operation, the contaminated soil at the top of the trench would be stabilized with shotcrete. All internal surfaces of the enclosure would be sprayed with a fixative. The enclosure would be dismantled and disposed. A soil ramp would be installed into the trench, providing access for borehole drilling. Because of the contaminants and concentrations within the trench, dismantling and disposing the enclosure would likely cost several million dollars. Rough order-of-magnitude drilling and analytical costs are estimated to be nearly $1,000,000.
	Install one vadose borehole within the trench boundaries at the location with the highest contamination potential. Location will be based upon process knowledge of the trench construction. Borehole will be drilled to the water table. Soil samples will be collected in specific strata at the following intervals:	Soil samples will be used to determine type and concentration of COCs beneath the trench in the vadose zone. Sampling provides data for remedial action decision making, to confirm the preliminary conceptual contaminant distribution model, and to support contaminant transport modeling.
	• Soils within the crib structure: – Collect one sample at approximately 5.5 m (18 ft).	Extreme contamination expected in this region. This sample will only be analyzed for chemical constituents because the TRU/radiological status is known.
	• Highest contaminant concentration layer (H_1): – Collect one sample at approximately 7.6 m (25 ft).	TRU contamination levels are expected through layer H_1 based on historical data (Smith 1973). This sample will only be analyzed for chemical constituents because the TRU/radiological status is known.
	• Highest contaminant concentration layer (H_2): – Collect one sample at the onset of this layer, presumed to be 20 m (69 ft).	TRU contamination levels may be present through layer H_2 based on historical data (Smith 1973). This sample will be analyzed for all COCs to confirm the vertical extent of the TRU contamination and to fill the chemical constituent data gap.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	• Moderate-to-low contaminant concentration fine-grained Plio-pleistocene layer: – Collect one sample at the onset of the Plio-pleistocene layer, presumed to be at 32 m (105 ft).	This region is expected to mark the onset of moderate radiological concentrations. Analyze for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample at the onset of the R_E layer, presumed to be at 37 m (121 ft).	The Ringold E Formation consists of gravel and sand and is expected to mark the onset of low radiological concentrations. The sample in this layer will be used to determine the changes from the Plio-pleistocene layer above and will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample at the midpoint of the R_E layer at 52 m (170 ft).	Because the Ringold E Formation is very deep, one sample is collected at the midpoint to avoid a large spatial data gap. Analyze for all COCs.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample just above the water table (approximately 67 m [220 ft]).	One sample will be used to determine the concentrations just above the water table. Analyze for all COCs.
	• Collect bulk density and grain-size distribution samples at major changes in lithology. Moisture samples will be collected with the other physical samples. Specific intervals will be defined in the SAP.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling.
Borehole geophysical logging	Perform borehole geophysical logging from the surface to groundwater.	Logging will provide a continuous profile that confirms the vertical distribution of transuranic contaminants.
	Perform neutron moisture logging from surface to groundwater.	Collect soil moisture data to support contaminant transport modeling.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-Z-9 Trench Alternative IV – Angle Drilling		
Borehole characterization	Drill two angle boreholes adjacent to the trench to capture samples from the soils beneath the trench. Because of the angled drilling geometry, it is not possible to collect samples from the soils immediately beneath the trench. Drill placement will be chosen to maximize the capture of samples under the footprint of the trench. However, practical factors, such as access requirements must be factored into selection of drilling locations:	Use of angle drill rig allows collection of soil samples from beneath the trench without special access provisions. Two boreholes are used to optimize the collection of samples beneath the trench. Refer to Figure 7-5 for conceptual angle drilling borehole configurations at 216-Z-9-Trench. Drill boreholes to allow soil sampling with depth and to support geophysical logging.
	• Highest contaminant concentration layers (H_1 and H_2): – Borehole A: Collect one sample at the onset of this layer, presumed to be 20 m (69 ft).	TRU contamination levels may be present through both layers H_1 and H_2 based on historical data (Smith 1973). This sample will be analyzed for all COCs to confirm the vertical extent of the TRU contamination and to fill the chemical constituent data gap.
	• Moderate-to-low contaminant concentration fine-grained Plio-pleistocene layer: – Borehole A: Collect one sample at the onset of the Plio-pleistocene layer, presumed to be at 32 m (105 ft). – Borehole B: Collect one sample at the onset of the Plio-pleistocene layer, presumed to be at 32 m (105 ft).	This region is expected to mark the onset of moderate radiological concentrations. Analyze for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Borehole A: Collect one sample at the onset of the R_E layer, presumed to be at 37 m (121 ft). – Borehole B: Collect one sample at the onset of the R_E layer, presumed to be at 37 m (121 ft).	The Ringold E Formation consists of gravel and sand and is expected to mark the onset of low radiological concentrations. One sample in this layer will be used to determine the changes from the Plio-pleistocene layer above. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Borehole B: Collect one sample at the midpoint of the R_E layer at 52 m (170 ft).	Because the Ringold E Formation is very deep, one sample is collected at the midpoint to avoid a large spatial data gap.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	• Low contaminant concentration Ringold E Formation (R_E): – Borehole B: Collect one sample just above the water table (approximately 67 m [220 ft]).	One sample will be used to determine the concentrations just above the water table. The sample will be analyzed for all COCs.
	– Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples. Specific intervals to be defined in SAP.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling.
Borehole geophysical logging	Perform borehole geophysical logging in both boreholes.	Logging will provide a continuous profile that confirms the vertical distribution of transuranic contaminants.
	Perform neutron moisture logging in both boreholes.	Collect soil moisture data to support contaminant transport modeling.
216-Z-9 Trench Alternative V – Drive Casing Sampling Through an Enclosure Riser with Pile Driver		
Drive casing sampling	Install drive casing with pile driver through an existing riser, or through a new one. Sample using a liner inside casing. Withdraw casing liner with pile driver and crane. Sampling locations to be determined after casing liner has been retrieved. Remove outer drive casing after geophysical logging. Soil samples will be collected in specific strata at the following intervals until refusal:	Pile driver may be used to remotely install drive casing through a riser in the enclosure roof without putting a vertical load on the trench roof. A substantial contamination control system and sleeving will be required during operation. Use of liner inside the casing will maximize soil retention during retrieval of the liner. This operation would require significant coordination with PHMC and DOE and may require a structural analysis of enclosure roof and/or creation of new access riser.
	• Soils within the crib structure: – Collect one sample at approximately 5.5 m (18 ft).	Extreme contamination expected in this region. This sample will only be analyzed for chemical constituents because the TRU/radiological status is known.
	• Highest contaminant concentration layer (H_1): – Collect one sample at approximately 7.6 m (25 ft).	TRU contamination levels are expected through layer H_1 based on historical data (Smith 1973). This sample will only be analyzed for chemical constituents because the TRU/radiological status is known.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	• Highest contaminant concentration layer (H_2): – Collect one sample at the [illegible] this layer, presumed to be 20 [illegible] (69 ft).	TRU contamination levels may be present through both layers H_1 and H_2 based on historical data (Smith 1973). This sample will be analyzed for all COCs to confirm the vertical extent of the TRU contamination and to fill the chemical constituent data gap. Drive casing is not expected to penetrate below this elevation.
Geophysical logging in drive casing	Perform borehole geophysical logging in drive casing.	Logging will provide a continuous profile that confirms the vertical distribution of transuranic contaminants.
	Perform neutron moisture logging in drive casing.	Collect soil moisture data to support contaminant transport modeling.
216-Z-9 Trench Alternative VI – GeoProbe/Cone Penetrometer Push Rods for Geophysical Logging Through an Enclosure Riser		
Sample soils through GeoProbe rods	Install an outer support pipe through enclosure riser. Install portable GeoProbe unit atop enclosure roof. Push rods through available riser until refusal.	An outer support pipe is required to provide lateral support for GeoProbe rods over the 6.1-m (20-ft) air gap from the enclosure roof to the trench floor. This operation requires significant coordination with PHMC and DOE, a structural analysis of the enclosure roof, special framework and installation, and may require a new access riser. A substantial contamination control system will be required during operation.
	Sample through upper trench and collect continuous soil sample or discrete samples with GeoProbe rods until refusal.	GeoProbe rods can be pushed for continuous sampling or can be installed and retrieved for discrete sampling.
Sample vapors through GeoProbe/ cone penetrometer rods	Sample carbon tetrachloride vapors at specified depth intervals until refusal.	Use GeoProbe rods outfitted with vapor sampling ports.
Geophysical logging in GeoProbe/cone penetrometer rods	Perform borehole geophysical logging in GeoProbe/cone penetrometer rods.	Logging will provide a continuous profile that confirms the vertical distribution of transuranic contaminants.
	Perform neutron moisture logging in GeoProbe/cone penetrometer rods.	Collect soil moisture data to support contaminant transport modeling.

Table 7-5. Sampling Design Alternatives. (8 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-Z-9 Trench Alternative VII – No Further Characterization Alternative		
No action	Determine whether the existing characterization data identifies the TRU and greater than Class C decision as the RI/FS decision-making risk driver.	Avoid unnecessary cost and worker exposure for collection of soil samples.

PHMC = Project Hanford Management Contractor

7.4.2 Evaluation of Alternative Sampling Designs

7.4.2.1 Alternative I – Borehole Drilling in Vicinity of Well 299-W18-159. The Alternative I sampling design for the 216-Z-1A Tile Field follows the focused sampling concept (Ecology 1995). The sampling intervals shown in Table 7-5 provide a useful vertical profile of contaminants through the waste site. It was determined that sufficient radiological data exist in the highest contamination concentration interval (H_1). Therefore, the COC list was revised to eliminate the radiological constituents in the H_1 layer. Because this alternative fills the data gaps and enables confirmation of historical radiological data, it is the recommended alternative.

7.4.2.2 Alternative II – No Further Characterization. Alternative II applies to the 216-Z-1A Tile Field. It is based on the observation that the TRU-contaminated and greater than Class C status of the site could be the RI/FS risk driver for this site and that further characterization efforts may not affect the outcome of remedial decision making. This alternative offers potential cost savings and as low as reasonably achievable (ALARA) benefits; however, it does not provide waste inventory data that would support selection of certain remedial actions (notably the engineered multimedia barrier). Therefore, this alternative is not recommended for further evaluation.

7.4.2.3 Alternative III – Conventional Drilling Through the Trench. This alternative provides a vertical profile of COCs to verify the preliminary conceptual contaminant distribution model. The disadvantages of this alternative are the high costs with little gain to the RI/FS process, as the expense associated with this alternative only adds data from the region immediately beneath the waste site, which is not a particularly sensitive data gap. In addition, this alternative would require extreme contamination-control measures. For these reasons, Alternative III is not recommended for further evaluation.

7.4.2.4 Alternative IV – Angle Drilling. Alternative IV involves collecting samples under the trench without the need for decommissioning the existing structure. Angle drilling does not provide an optimized vertical contaminant profile but does provide good characterization in the lower portion of the vadose zone. The cost of this alternative is expected to be significantly less than the cost of Alternative III.

Figure 7-1. Plan View of the 216-Z-1A Tile Field.

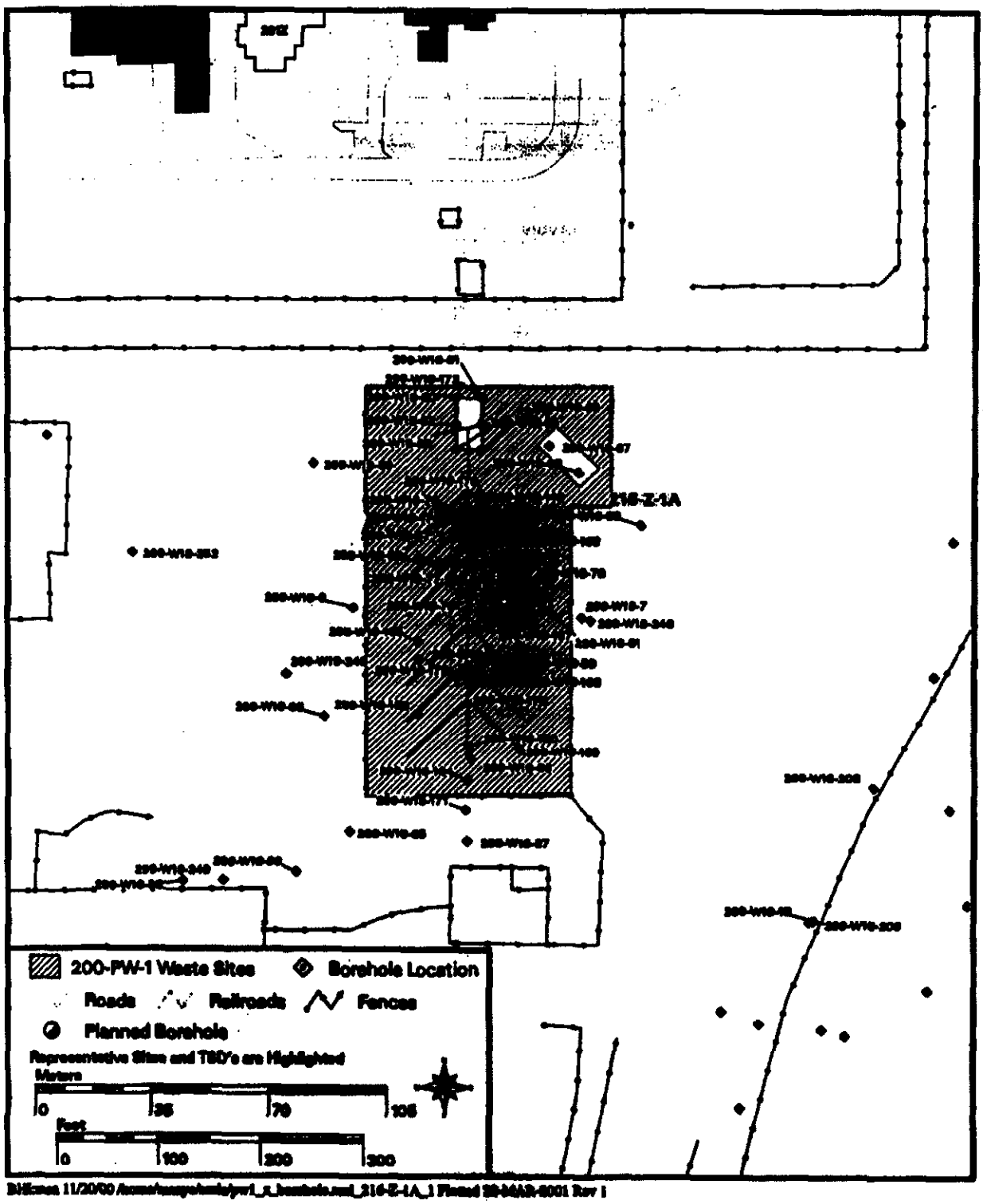


Figure 7-2. Conceptual Diagram of Borehole in the 216-Z-1A Tile Field.

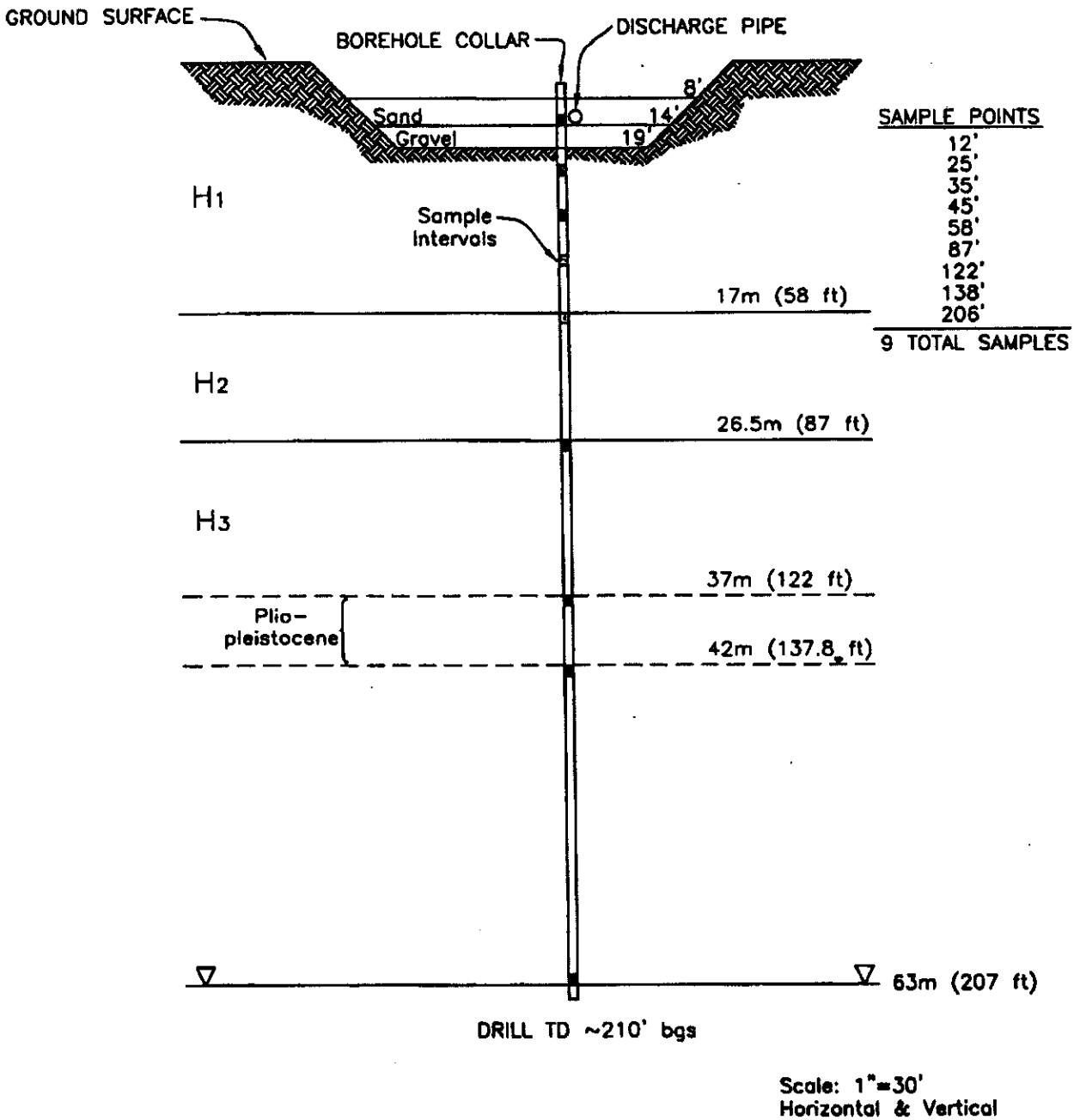


Figure 7-3. Plan View of the 216-Z-9 Trench.

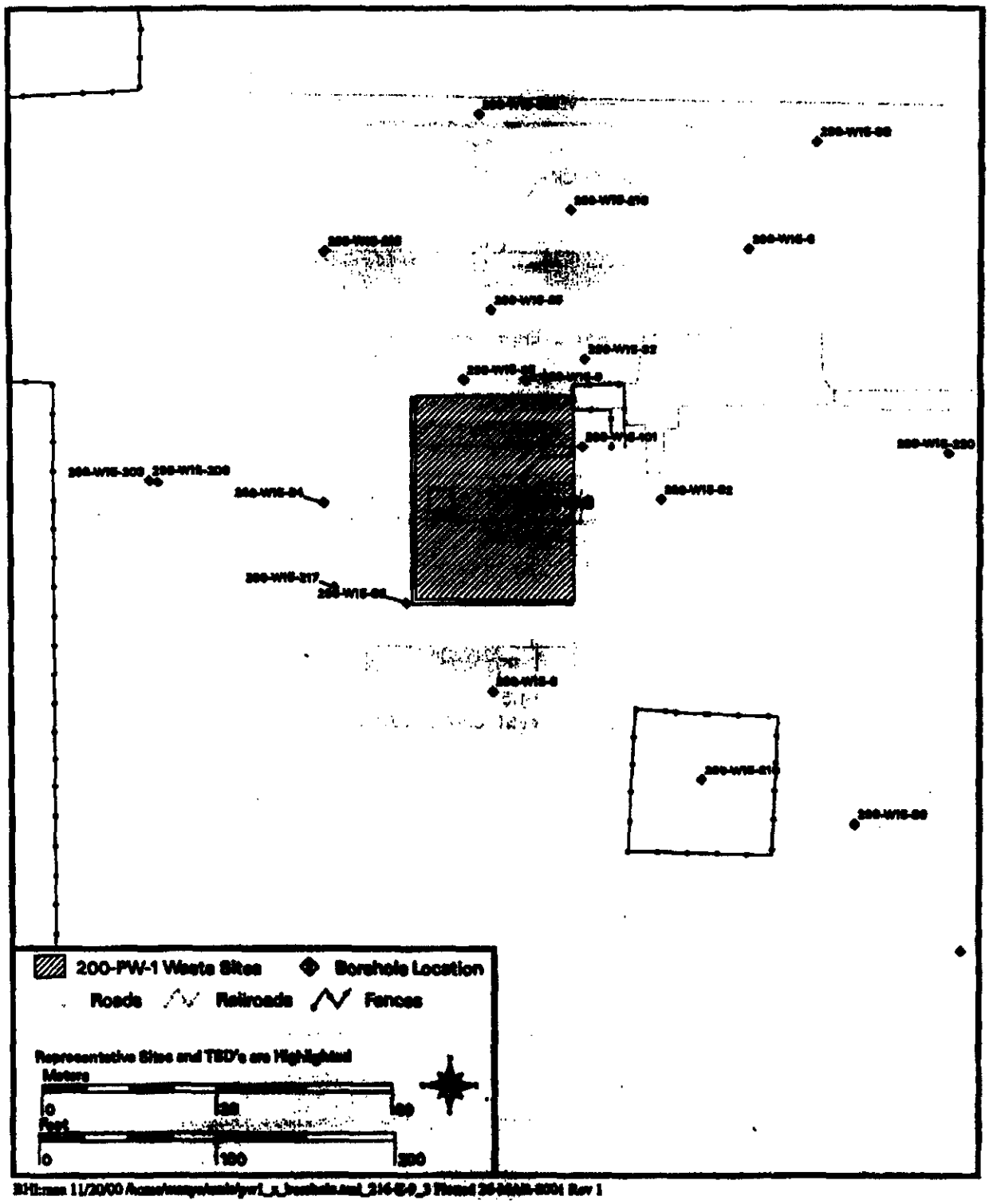


Figure 7-4. Section View of the 216-Z-9 Trench.

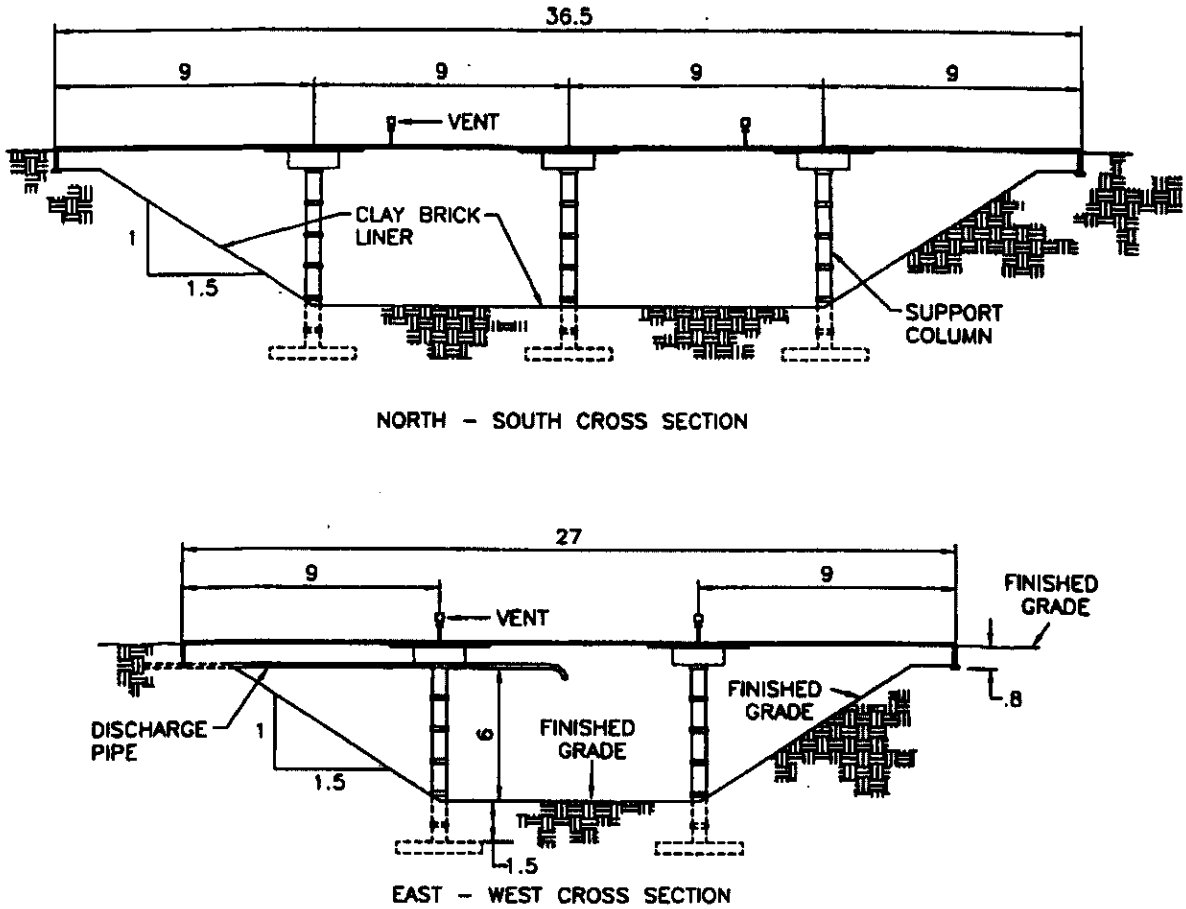
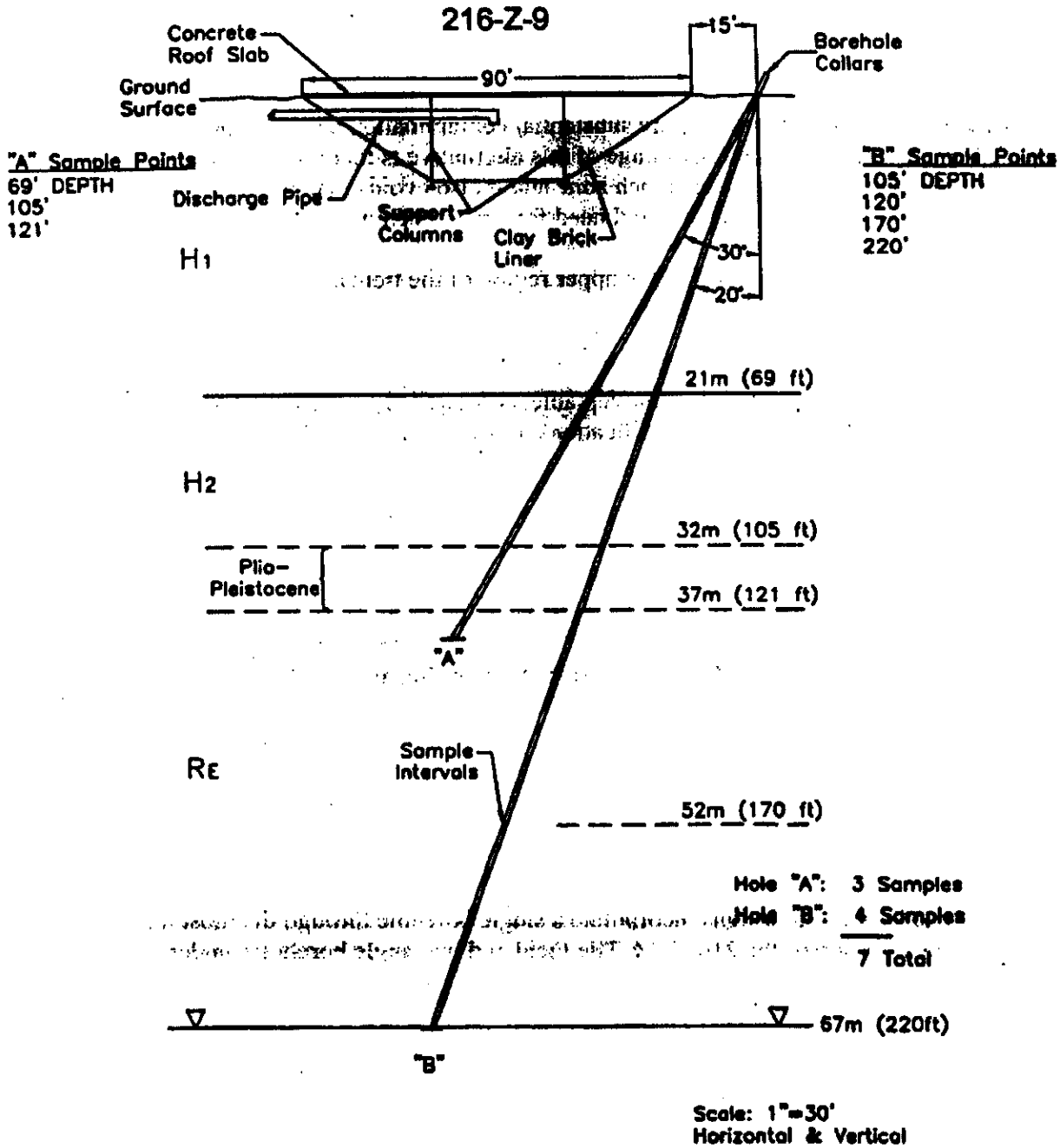


Figure 7-5. Conceptual Diagram of the Angle Drilling Boreholes.



7.4.2.5 Because this alternative fills identified data gaps beneath the waste site without a major project preparation activity and is a proven technology, Alternative IV is the proposed alternative for the 216-Z-9 Trench.

7.4.2.6 Alternative V – Drive Casing Sampling Through an Enclosure Riser with Pile Driver. Alternative V would require substantial contamination controls and coordination with DOE, FH, and the ERC. The advantage of this alternative is that it is a relatively low-cost approach for sampling the upper trench zone and it also avoids placing stress on the trench roof. The disadvantages include the potential need for a new opening in the trench enclosure and the possible loss of sample media during casing extraction. This alternative may be evaluated further for collection of samples in the upper region of the trench.

7.4.2.7 Alternative VI – GeoProbe/Cone Penetrometer Push Rods for Geophysical Logging Through an Enclosure Riser. Alternative VI is similar to Alternative IV but would place loads on the enclosure roof that may be unacceptable; consequently, a structural analysis would be required for the enclosure roof. Modifications may be required to the enclosure prior to implementation. In addition, a guard pipe would need to be installed to provide lateral support for the GeoProbe rods in the 6.1-m (20-ft) unsupported zone between the bottom of the GeoProbe unit and the onset of trench soil. For these reasons, Alternative VI is not considered further.

7.4.2.8 Alternative VII – No-Further Characterization Alternative. Alternative VII applies to the 216-Z-9 Trench and is based on the observation that the TRU and greater than Class C status of the site could be the RI/FS risk driver for this site, and that further characterization efforts may not affect the outcome of remedial decision making. This alternative offers potential cost savings and ALARA benefits; however, this alternative does not provide waste inventory data that would support selection of certain remedial actions (notably the engineered multimedia barrier). Therefore, Alternative VII is not recommended for further evaluation.

7.4.3 Proposed Sampling Designs

The proposed sampling designs incorporate a single borehole through the most highly contaminated portion of the 216-Z-1A Tile Field and two angle boreholes under the 216-Z-9 Trench. These designs provide safe, reliable, and cost-effective sampling methods that satisfy the identified data needs. The sampling designs for these two sites are integrated because the chemical contamination data from the upper 18.3 m (60 ft) of the 216-Z-1A Tile Field will be used to fill a data gap in the upper region of the 216-Z-9 Trench. This is necessary because the angle-drilling concept applied to the 216-Z-9 Trench does not permit the collection of soil samples from the upper 18.3 m (60 ft) of the site (see Figure 7-5).

The process history for these two sites was evaluated to determine the degree of similarity in the waste streams before the 216-Z-1A Tile Field chemical data could be applied to the 216-Z-9 Trench. The review of historical data and an interview with Z Plant operating personnel[1] indicated that the waste streams differed between the two sites, principally in waste

[1] M. L. Yates, personal interview on February 27, 2001, with Mr. Thurman Cooper, PFP Chemist.

discharge concentrations. The same chemicals were released to both sites; however, the 216-Z-9 Trench received the more highly concentrated discharge waste streams. The only known exception is that cadmium-nitrate was deliberately released to the 216-Z-9 Trench for criticality control near the end of the trench's operating life. Cadmium concentrations were reported in samples from the 216-Z-9 Trench (Smith 1973).

Because the chemical discharges to both sites involved the same chemistry (with the exception of the cadmium-nitrate), the use of the 216-Z-1A chemical data from the upper regions of the site is considered to be appropriate but may be at lower concentrations than in the 216-Z-9 Trench. The chemical analytical data obtained from both sites will be analyzed. Extrapolations may be necessary with the 216-Z-1A data for use in the uppermost region of the 216-Z-9 Trench.

The sampling designs proposed for the 216-Z-1A Tile Field and 216-Z-9 Trench are presented in Table 7-6.

Table 7-6. Proposed Sampling Designs. (4 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-Z-1A Tile Field Alternative 1–Borehole Drilling in Vicinity of Well 299-W18-159		
Borehole characterization	Install one vadose borehole in close proximity to the 299-W18-159 borehole, which is near the center of the tile field. Refer to Figures 7-1 and 7-2. Soil samples will be collected in specific strata at the following intervals:	The 299-W18-159 borehole spectral gamma logging results indicate that the soils in the vicinity of this borehole have higher contamination levels than any other borehole that was logged. The borehole will be drilled from the surface to the water table for borehole soil sampling.
	• Highest contaminant concentration layer (H_1): – Collect one sample at 3.7 m (12 ft). – Collect one sample at the onset of native soils beneath the tile field gravel bed, presumed to be at 7.6 m (25 ft). – Collect samples at 10.7 m and 13.7 m (35 ft and 45 ft).	The radiological contamination concentrations in this region are above the TRU definition (PNNL 1998). The 3.7-m (12-ft) sample is within the sand layer of the most highly contaminated region of the tile field (PNNL 1999b). The sand is more likely to yield a sample than the gravel layer beneath it. The 7.6-m (25-ft) region is expected to contain TRU-contaminated soils, but at significantly lower concentrations than the 3.7 m (12 ft) depth. The two deeper samples will complete a vertical contaminant concentration profile within this highly contaminated layer. None of the samples collected within the H_1 layer will be analyzed for radiological COCs because there is no radiological data gap in this depth interval.

Table 7-6. Proposed Sampling Designs. (4 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	• Low contaminant concentration sand layer (H_2): – Collect one sample at the onset of this formation, presumed to be 17 m (58 ft).	Historical data shows TRU contamination to a depth of approximately 17.7 m (58 ft). This region is expected to delineate the shift to low radiological concentrations. The sample will only be analyzed for the chemical COCs to fill that data gap.
	• Low contaminant concentration gravel layer (H_3): – Collect one sample at the onset of this formation, presumed to be 26.5 m (87 ft).	One sample in this layer will be used to determine the concentration changes from the H_2 layer above. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Plio-pleistocene layer: – Collect one sample at the onset of this formation, presumed to be 37.2 m (122 ft).	The sample in this layer will be used to determine the changes from the H_3 layer above. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample at the onset of this formation, presumed to be 47 m (138 ft).	The Ringold E Formation consists of gravels and sand. The sample in this layer will be used to determine the changes from the Plio-pleistocene layer above. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Collect one sample just above the water table (approximately 63 m [207 ft]).	One sample will be used to determine the concentrations just above the water table. The sample will be analyzed for all COCs.
	– Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples. Specific intervals to be defined in SAP.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support modeling.
	Geophysically log the borehole.	Log the vertical distribution of radiological contaminants to confirm analytical data and refine preliminary conceptual contaminant distribution model.
		Perform neutron moisture logging to support contaminant transport modeling.

Table 7-6. Proposed Sampling Designs. (4 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-Z-9 Trench Alternative III – Angle Drilling		
Borehole characterization	Drill two angle boreholes adjacent to the trench to capture samples from the soils beneath the trench. Because of the angled drilling geometry, it is not possible to collect samples from the soils immediately beneath the trench. Drill placement will be chosen to maximize the capture of samples under the footprint of the trench. However, practical factors, such as access requirements must be factored into selection of drilling locations.	Use of angle drill rig allows collection of soil samples from beneath the trench without special access provisions. Two boreholes are used to optimize the collection of samples beneath the trench. Refer to Figure 7-5 for conceptual angle drilling borehole configurations at 216-Z-9 Trench. Drill boreholes to allow soil sampling with depth and to support geophysical logging.
	• Highest contaminant concentration layers (H_1 and H_2): – Borehole A: Collect one sample at the onset of this layer, presumed to be 20 m (69 ft).	TRU contamination levels may be present through both layers H_1 and H_2 based on historical data (Smith 1973). This sample will be analyzed for all COCs to confirm the vertical extent of the TRU contamination and to fill the chemical constituent data gap.
	• Moderate-to-low contaminant concentration fine-grained Plio-pleistocene layer: – Borehole A: Collect one sample at the onset of the Plio-pleistocene layer, presumed to be at 32 m (105 ft). – Borehole B: Collect one sample at the onset of the Plio-pleistocene layer, presumed to be at 32 m (105 ft).	This region is expected to mark the onset of moderate radiological concentrations. Analyze for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E Formation (R_E): – Borehole A: Collect one sample at the onset of the R_E layer, presumed to be at 37 m (121 ft). – Borehole B: Collect one sample at the onset of the R_E layer, presumed to be at 37 m (121 ft).	The Ringold E Formation consists of gravel and sand and is expected to mark the onset of low radiological concentrations. One sample in this layer will be used to determine the changes from the Plio-pleistocene layer above. The sample will be analyzed for all COCs to obtain contaminant concentrations at this change in lithology.
	• Low contaminant concentration Ringold E formation (R_E): – Borehole B: Collect one sample at the midpoint of the R_E layer, at 52 m (170 ft).	Because the Ringold E Formation is very deep, one sample is collected at the midpoint to avoid a large spatial data gap.

Table 7-6. Proposed Sampling Designs. (4 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	• Low contaminant concentration Ringold E Formation (R_E): – Borehole B: Collect one sample just above the water table (approximately 67 m [220 ft]).	One sample will be used to determine the concentrations just above the water table. The sample will be analyzed for all COCs.
	– Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples. Specific intervals to be defined in SAP.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling.
Geophysical logging	Perform borehole geophysical logging in both boreholes.	Logging will provide a continuous profile that confirms the vertical distribution of transuranic contaminants.
	Perform neutron moisture logging in both boreholes.	Collect soil moisture data to support contaminant transport modeling.

7.5 POTENTIAL SAMPLE DESIGN LIMITATIONS

Potential sample design limitations are as follows:

- The 216-Z-9 Trench is not accessible for installation of conventional drilling equipment. Alternate drilling methods/approaches (e.g., angle drilling) must be used to protect the concrete enclosure roof from unacceptable loads.

- Contamination levels in both waste sites are significant and will require employment of substantial contamination controls to ensure the health and safety of workers and protection of the environment and equipment. Such controls may restrict the movement of workers. Samples with high contamination levels may be reduced in volume to permit shipment to laboratories. However, this may hinder the ability of the laboratories to meet quality assurance/quality control requirements.

- Drilling impediments (e.g., boulders) may be encountered and/or insufficient sample volumes may be retrieved from the split-spoon samplers. The list of analytes will be prioritized in the SAP to account for insufficient sample volume.

- Drilling will generate excessive heat and may volatilize the VOAs that are present within the soil. This may affect the accuracy of the VOA measurements.

- Because the potential exists for significant concentrations of radiological COCs, samples may need to be analyzed in an onsite laboratory. In this case, expected impacts include high

analytical costs, degradation of detection limits, reduced analyte lists, and long turnaround times. The presence of TRU-contaminated soil would also significantly impact waste handling and management. Sample volumes may be reduced if the radiation levels for the samples are too high.

- Analysis of VOA contaminants imposes sample hold-time limitations. To overcome these limits, prior planning and coordination are recommended to avoid violating the hold-time limits.

- The sampling intervals developed in this DQO summary report may be adjusted in the SAP to account for refinements to the sampling design.

8.0 REFERENCES

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